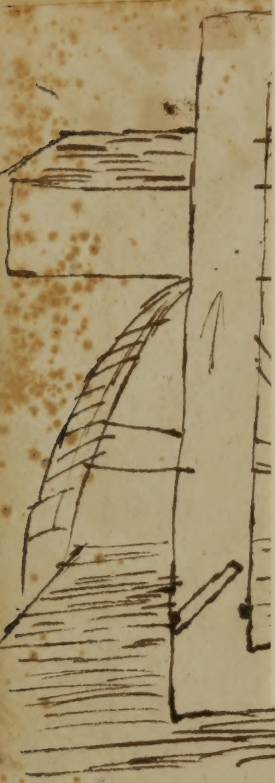

James C. Hall
Philadelphia
No 59 S. S.

MINUTES

OF THE

COURSE OF CHEMICAL INSTRUCTION

IN THE

MEDICAL DEPARTMENT

OF

The University of Pennsylvania.

BY

ROBERT HARE, M.D.

PROFESSOR OF CHEMISTRY.

FOR THE USE OF HIS PUPILS.

REPRINTED, WITH CORRECTIONS AND ADDITIONS.

PHILADELPHIA:

Clark & Raser, Printers, No. 33, Carter's Alley.

1825.

It is the object of Chemistry to investigate all changes in the constitution of matter, whether effected by heat, moisture or other means (Brande)

Attraction may be considered as acting at sensible & insensible distances; The former is called Gravitation and acts directly as the mass and inversely as the squares of the distances — Solution is necessary to crystallization — more perfect when slowly performed — The hardness of many crystals depends on their water, as sal. lime, sal. soda — Light influences crystallization — The reflexion of ~~light~~ air in some cases depends on electrical changes — The primitive forms of Crystals are six 1 Cube 2 Octaedron 3 Octoedron 4 Hexangular prism 5 Rhomboid dodecaedron 6 dodecedron with isosceles triangular faces

Minutes are hours, when Lovers stay away
But minutes, if there, hours are like days

MINUTES,

&c. &c.

INTRODUCTORY LECTURE,

ON THE RISE, PROGRESS, AND PRESENT STATE OF CHEMISTRY, AS AN ART, AND AS A SCIENCE.

LECTURE

ON THE STUDY OF CHEMISTRY.

ON THE CAUSE OF THE PHENOMENA AND OPERATIONS OF THE PHYSICAL WORLD.

REACTION between different portions of matter, is conceived to be the fundamental cause of the phenomena and operations of the physical world; for if there were no such reaction, every particle, or mass, would be as if no other existed.

REACTION,*

Is distinguished as taking place between masses, between a mass and particles, and between particles only.

REACTION BETWEEN MASSES,

Is sublimely exemplified in the solar system.

REACTION BETWEEN A MASS, AND PARTICLES,

Is exemplified by the reflection, refraction, or polarization of light; as by the moon, the rainbow, the Iceland spar.

REACTION BETWEEN PARTICLES, OR CORPUSCULAR REACTION,

Is exemplified by a fire or the explosion of gunpowder.

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* In Mechanicks, action is said to produce reaction: but in the case of an innate property, which mutually causes different portions of matter to be self-attractive, or repellent, it is impossible to distinguish the agent from the re-agent. From our first acquaintance with any bodies so situated, they may be said mutually to react, or to exercise reaction. Hence I employ this word, to distinguish the action which bodies exert, reciprocally, from any joint action against other bodies.

NATURAL PHILOSOPHY DEFINED.

In its most extensive sense, it treats of physical reaction generally. In its more limited and usual acceptation, it treats of those phenomena, or operations of nature, which arise from reaction between masses, or between a mass and particles.

CHEMISTRY DEFINED.

It treats of the phenomena, and operations of nature, which arise from reaction between the particles of inorganic matter.

PHYSIOLOGY DEFINED.

Physiology treats of the phenomena and operations, which arise from reaction between the masses, or atoms, of organic, or living bodies.

THE REACTION OF PARTICLES, OR CORPUSCULAR REACTION,

Is distinguished into repulsive reaction, or repulsion, and attractive reaction, or attraction.

OF ATTRACTION.

Attraction is distinguished, as it takes place between particles, of the same kind, or, homogeneous; and as it exists between particles of a different kind, or, heterogeneous.

The attraction which takes place between homogeneous particles, is designated as attraction, of aggregation, of cohesion, or as homogeneous affinity. The attraction which arises between heterogeneous particles, is called chemical affinity, or heterogeneous affinity.

ON ATTRACTION OF AGGREGATION, OR COHESION: ALSO CALLED HOMOGENEOUS AFFINITY.

It is the force which mechanical division subdues.* Overcoming it, does not alter the *chemical* nature of a substance. It is the cause of crystallization.

CRYSTALLIZATION,

Is that process of nature, by which bodies, passing from the fluid to the solid state, assume regular forms called crystals. All matter is presumed to be capable of assuming crystalline forms.

CRYSTALS,

Are found in nature and are produced artificially.

EXAMPLES OF NATIVE CRYSTALS.

The precious stones are splendid productions of this kind. Calcareous spar, common salt, gypsum, are native products, often crystalline in form.

ON THE VARIOUS MEANS OF CAUSING ARTIFICIAL CRYSTALLIZATION.

Fusion followed by congelation.—Instances: Sulphur, bismuth, antimony, zinc.

Solution followed by evaporation in open vessels.—Exemplified by salts, acids, alkalies, sugar.

Solution with heat, followed by refrigeration.

Most of the substances which yield crystals by the process last mentioned, yield them likewise in this way.

Solution followed by vaporization at the boiling heat.

Crystals may be thus obtained from many salts; but are always minute—as in the case of basket salt.

Solution followed by saturation.—Instances: Pearl ash saturated by carbonic acid or chlorine.

Sublimation.—This comprises the idea of vaporization and condensation. Instances: Corrosive sublimate, calomel, iodine, arsenic.

Solution followed by precipitation.—Arbor Dianæ, arbor Saturni.

SUBJECT OF CRYSTALLIZATION CONTINUED.

Other things being equal, crystals are larger in proportion as their growth is slower. They prefer to shoot from extraneous bodies, as the sides of the receptacle, or from strings, or sticks, to forming themselves in an isolated manner. Agitation hastens their production, but confuses them. The crystalline texture of some of the trap rocks, is attributed to slow cooling. The same matter fused, and allowed less time to cool, forms a glass.

CRYSTALLINE SPECIMENS.

A wooden arch, about fifteen inches high, and a foot wide, encrusted with fine blue crystals of the sulphate of copper.

Crystals of corrosive sublimate, and of calomel.

Crystals of sulphur, arsenic, bismuth, antimony, and various other specimens.

EXPERIMENTAL ILLUSTRATION

Of the consequences of excluding the air from a saturated solution of sulphate of soda, while boiling.

RATIONALE OF THE PROCESS OF CRYSTALLIZATION.

OF THE OBSERVATIONS OF ROME DE L'ISLE, OF GHAN, OF BERGMAN, OF HAUY.

OF HAUY'S CRYSTALLOGRAPHY.

OF THE ATTRACTION, WHICH OPERATES BETWEEN HETEROGENEOUS PARTICLES; CALLED AFFINITY, OR HETEROGENEOUS AFFINITY.

This attraction is never subdued mechanically, unless when nearly balanced by repulsion; as in the case of compounds, which

may be exploded by percussion, or elastic fluids condensed into, or combined with, liquids.

To sever elements, united by chemical affinity, the finest edge which human art can produce, were utterly incompetent.

Instances:—

Whiting consists of lime and carbonic acid; Plaster of Paris, of sulphuric acid and lime; Vermilion, of sulphur and mercury. These substances may be reduced into powders perfectly impalpable. Yet the minutest particle of either contains the same ingredients as the mass, and in the same proportion.

DIFFERENT CASES OF AFFINITY, ACCORDINGLY AS MORE OR FEWER PARTICLES ARE CONCERNED.

1st case—Simple Combination.

A and B, two heterogeneous substances, united in the compound AB.

Instances:—

Copper and zinc	form	Brass.
Lead and tin	,,	Pewter.
Oil and alkali	,,	Soap.
Acids and alkalies	,,	Salts.
Chlorine and metals	,,	Chlorides, as for instance calomel or corrosive sublimate.
Sulphur and metals	,,	Sulphurets.

2d Case of Affinity.

Called simple elective attraction, or affinity.

A and B, two heterogeneous particles, being united in compound AB,—C, another particle, being blended with them in solution, unites with one of them, as A, to the exclusion of B.

In this case, C is said to decompose AB, and to have a greater affinity for A than B.

Instances of simple elective affinity:—

Nitrate	of Silver	decomposed by	Mercury.
	of Mercury	,,	Copper.
	of Copper	,,	Iron.
Muriate of Lime		,,	Sulphuric Acid.
Sulphate	of Alumine / of Magnesia	,,	Potash.

3d Case of Affinity.

Called double elective attraction, or complex affinity.

The compound formed by the particles A and B, being blended in solution with the compound formed by C and D,—A combines with D, and B with C.

Muriatic & ammoniacal gases produce
sim. ammonia, which is a solid
The fixed gas & chlorine form a liquid
Glauber's salt & nitrate of ammonia by
being triturated form a liquid
Solutions of mur. lime & carb. potasa
form a solid
Oxygen, sulphur & water, themselves in-
ert form sulph. acid
Potasa (a caustic) & sul. acid form a
salt of bitter activity
The colour, temperature, & specific gravi-
ty of bodies alter by union

Saturation is applied to the solution of bodies when complete.
Neutralization when the individual properties are lost.

Instance of double elective affinity:—

A	B		A	D
Sulphate of	Zinc		Sulphate of	Lead
being mixed with		gives	and	
Acetate of	Lead,		Acetate of	Zinc.
C	D		C	B

VARIOUS OTHER EXPERIMENTAL ILLUSTRATIONS.

4TH CASE OF AFFINITY.

A, B, and C, being in union, on adding D, it combines with B, which it would not do were not C present.

Instance:—Ammoniacal nitrate of copper, or silver, added to a solution of white arsenic in water. The arsenious solution will not, per se, decompose the nitrates.

5TH CASE OF AFFINITY.

A and B, being in union, C, added in *excess*, combines with both A and B.

Instance:—Ammonia added to solutions of copper, or silver, gold, &c.

ON COHESION AS AN OPPONENT OF CHEMICAL COMBINATION.

EFFECTS OF MECHANICAL DIVISION EXPERIMENTALLY ILLUSTRATED.

Action of an acid upon a lump of metal, compared with the action of the same acid upon an equal weight of the same metal in filings.

INFLUENCE OF SOLUTION EXPERIMENTALLY ILLUSTRATED.

Tartaric acid, and a carbonate, although pulverized, and intimately intermingled, are observed not to react until moistened, when a lively effervescence ensues.

EXCEPTION TO THE LAW, THAT CHEMICAL ACTION REQUIRES FLUIDITY—EXPERIMENTALLY ILLUSTRATED.

Quicklime and muriate of ammonia, being powdered and mixed, the pungent fumes of ammonia are perceived.

ON TABLES OF AFFINITY.

Any substance being placed at the head of a column, other substances are placed under it, in the order of their attraction for it.

AN EXAMPLE.

SULPHURIC ACID.

Barytes,
Strontites,
Potash,
Soda,
Lime,
Magnesia,
Ammonia.

ON DEFINITE PROPORTIONS.

The proportions have been long known to be invariable, in which substances must be mixed, in order to saturate each other; or to produce a compound, in which the peculiar characters, or affinities of the ingredients, are extinguished.

When substances combine in other proportions, than those of saturation, their ratio is no less definite, and constant.

There is not, in any case, except the peculiar one of solution, an indefinite gradation in the proportions in which bodies combine. There are rarely more than four gradations.

The number, representing the least proportion, in which a substance is known to combine, will almost always divide the numbers representing the greater proportions, without a fraction.

Let A, B, and C, be certain substances, and let X, Y, and Z, be other substances, severally having an affinity for either A, or B, or C. Let each of the former, and each of the latter, be combined in the least possible proportion. Consequently, the least combining proportion of each substance, will be found three times. It will appear that the proportions of A, B, and C, found by combining them with X, will be in the same ratios to each other, as the proportions found by combining them with Y, or Z; and reciprocally, that the proportions of X, Y, and Z, will have the same ratios, whether ascertained by their combination with A, B, or C.* This uniformity of the ratios existing, between the least combining proportions of substances, will be found to prevail, if, instead of six substances, the comparison be made with any larger number.

Chemical equivalents are numbers, representing the least combining proportions of the substances to which they belong. They are usually assumed so, as either to make the equivalent of oxygen, or that of hydrogen, unity.

TABLES OF CHEMICAL EQUIVALENTS,

Are very useful; for as the equivalent number of any compound, is to any weight of the compound, so is the equivalent of either of

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* That is, as A, in AX, is to B, in BX, or to C, in CX—so is A, in AY, to B, in BY, or to C, in CY:—and so is A, in AZ, to B, in BZ, or to C, in CZ.—Again, as X, in AX, is to Y, in AY, or to Z, in AZ—so is X, in BX, to Y, in BY, or to Z, in BZ:—and so is X, in CX, to Y, in CY, or to Z, in CZ.

its ingredients, to the quantity of such ingredient in the said weight of its compound.

And as the equivalent of any compound, is to that of any substance, capable of decomposing it; so is the weight of the compound, to be decomposed, to the weight of the substance, just adequate to effect the decomposition.

WOLLASTON'S SCALE OF EQUIVALENTS.

By this, the computations requisite in using the equivalents, are performed by a slide.

The equivalents may be expressed in any numbers having the same ratios to each other as the least combining proportions of the substances which they represent. The slide enables us to adopt such other numbers as may be convenient. Equal distances on the slide, give the same ratios in different numbers. If, by moving the slide, we vary one equivalent, to 100 for instance, the other equivalents vary proportionably.

THEORY OF ATOMS.

The ratio of the equivalent numbers, is supposed to be dependent on, and identical with, that of the integral atoms of the substances to which they appertain.

It is probable, that there are elementary atoms, indivisible either by mechanical, or chemical means. Mechanical division is limited by the imperfection of edges, or surfaces.—Were atoms chemically divisible, ad infinitum, any one substance, however small in quantity, would be equally diffusible throughout any other, however great. The fact is otherwise: whence, elementary atoms are inferred to be chemically indivisible.

BINARY COMPOUNDS.

A compound, in which the ingredients are both reduced to the smallest possible proportions, is considered as having as many atoms of the one as of the other; and each integral atom of the compound, as consisting of an atom of each ingredient. Such combinations are called binary, because they contain but two atoms.

TERNARY COMPOUNDS.

When the quantity of either ingredient is the double of its least proportion, it is supposed that the number of its atoms is doubled; and the other ingredient being in its least proportion, it is inferred that there are two atoms of the former to one of the latter; hence it has been called a ternary compound.

QUATERNARY COMPOUNDS,

Are those, in which the proportion of one of the ingredients is tripled, so that it is supposed to contain four atoms.

ON CALORIFIC REPULSION.

A PRIORI PROOFS, THAT THERE MUST BE A MATTER, IN WHICH REPULSION EXISTS AS AN INHERENT PROPERTY.

The existence of repulsion and attraction between the particles of matter, is as evident as that they exist. Opposite qualities, cannot belong to the same particles. There must be particles, in which repulsion is inherent, as well as others in which attraction is inherent.

EXPERIMENTAL PROOFS, OF THE EXISTENCE OF A MATERIAL CAUSE, OF CALORIFIC REPULSION.

If ice at 32° be mixed with water at 170°,—the mixture, when the ice is melted, will be at 32°. But if water at 32°, be mixed with water at 170°,—the mixture will be at a mean heat. Water exposed to a fire, does not grow hotter after it boils, but steams more or less, according to the activity of the fire. The steam appears to carry off the principle which the fire communicates. Steam, only heated to the boiling point, or 212°, will raise the temperature of nearly ten times its weight of water, 100 degrees.

INFERENCE.

The heat, which would raise ten parts of water to 100 degrees, if it were concentrated into one of those parts, would probably raise it to 1000 degrees nearly, which is about equal to a red heat. It follows, therefore, that as much heat is absorbed in producing steam, as would make the water, of which it consists, red hot, if prevented from assuming the aëriform state.

These facts, and deductions, induce chemists generally to believe, that the cause of calorific repulsion is material—that it consists of a fluid, of which the particles are self-repellent, while they attract other matter—that by the union of this fluid with other matter, it imparts a repulsive property which counteracts cohesion, so as to cause, successively, expansion, fluidity, and the aëriform state.

OF THE TERM CALORIC.

Propriety of using a new word (caloric) to designate the material cause of calorific repulsion, illustrated by a fulminating powder, which, though cold, contains more of the material cause of heat, than red-hot sand.

ORDER PURSUED IN TREATING OF CALORIC.

Of its effects. On the modification of the effects of Caloric by atmospheric pressure. Means of producing heat, or rendering Caloric sensible. On the communication of heat. Slow communication: Quick communication. Means of producing cold, or rendering Caloric latent. On the various states, wherein Caloric exists in nature.

The value of Redpoods instrument is lessened by the fact that a long endurance of a low heat, will decrease their size as much as the short endurance of a high heat.

Describe the original inventor of the thermometer

Air is unfitted unfit for thermometers from its weight & elasticity.

When the barometer rises, it marks fair weather when it falls, foul or windy weather

EXPANSION, THE MOST OBVIOUS, AND UNIVERSAL EFFECT OF CALORIC.

On the expansion of Solids. On the expansion of Liquids. On the expansion of Elastic Fluids. On the opponent agency of Atmospheric Pressure.

EXPANSION OF SOLIDS.

A ring and plug, which, when cold, fit each other, cease to do so when either is heated: and a tire, when *red-hot*, is made to embrace a wheel, otherwise too large for it.

A pyrometer shown, in which expansion is multiplied by levers.

Metals are the most expansible solids, but some are more expansible than others.

SUPPOSED EXCEPTION TO THE LAW, THAT SOLIDS EXPAND BY HEAT, IN THE CASE OF CLAY; WHICH CONTRACTS IN THE FIRE.

The clay loses bulk, by losing water. Granular aggregates sink before fusion. Each grain may expand, while the mass contracts. The size of the masses after fusion, probably would be found in proportion to their temperature.

WEDGWOOD'S PYROMETER.

The contraction, induced in cylinders of clay, in proportion as they have been heated, measured by a scale, supposed to indicate the heat to which they have been exposed.

Wedgwood's pyrometer exhibited.

EXPANSION OF FLUIDS, WHICH ARE ALMOST INCOMPRESSIBLE OR NON-ELASTIC, AS WATER, OIL, ALCOHOL.

For the sake of brevity, these will be called liquids.

LIQUIDS MORE EXPANSIBLE THAN SOLIDS.

Expansion of liquids, shown by matrasses with long narrow necks, filled to the origin of their necks with fluids differently coloured.

ON THERMOMETERS.

ON THE ORIGINAL INSTRUMENTS OF SANCTORIO AND VAN HELMONT, AND THE CAUSE OF THEIR IMPERFECTION.

ON MERCURIAL AND SPIRIT THERMOMETERS, AND THE METHOD OF FILLING AND GRADUATING THEM.

The distance between the freezing and the boiling points of water, is divided by Celsius into 100°, by Reaumur into 80°, and by Fahrenheit into 180°. Hence, it is evident, that the degrees of their thermometers, are, to each other, as those numbers—or as 10, 8, 18, or 5, 4, 9. The method of Celsius is the best—that of Fahrenheit the worst.

SELF-REGISTERING THERMOMETERS. PALM GLASS.

DIFFERENTIAL THERMOMETERS.

EXCEPTION TO THE LAW, THAT LIQUIDS EXPAND BY HEAT.

Between freezing and 40° (F.) water contracts. Ice is one-ninth more bulky than the water forming it. But for these properties, lakes and rivers might freeze to a depth destructive of aquatic animals, and so as not to thaw in summer.

EXPANSION OF ELASTIC FLUIDS.

The bulk of aëriform fluids is regulated by pressure as well as heat.

DEFINITION OF ELASTICITY.

It is the power of resuming shape, position, or bulk, on the cessation of constraint. The degree of it is not dependent on the *force*, but on the *perfection*, of recoil. A watch spring, is not less elastic than a coach spring. Atmospheric air, and all other aëriform fluids, are perfectly elastic. Elasticity is erroneously spoken of as a varying property in air.

MODIFICATION OF THE EFFECTS OF CALORIC BY ATMOSPHERIC PRESSURE.

DIGRESSION TO DEMONSTRATE THE NATURE AND EXTENT OF ATMOSPHERIC PRESSURE.

EXPERIMENTAL PROOF THAT AIR HAS WEIGHT.

The air being allowed to enter an exhausted globe, while accurately poised upon a scale beam, causes it to preponderate strikingly.

For, the pressure of any fluid upon any area, assumed within it, the pressure of a column, of any other fluid having said area for its base, may be substituted, without destroying the equilibrium, provided it be as much higher, as lighter, as much lower, as heavier: or in other words, the weights of the respective fluids, must be as their gravities, inversely.

Four glass jars, severally four inches in diameter, and thirty inches in height; in each a stratum of mercury about two inches deep:—also a tube, one and a half inches in diameter, exceeding jar, in height, one foot, and open at both ends—lower orifice under the mercury.

Water being poured into the jars until nearly full—for every foot which it rises in them, mercury elevated, in tubes, nearly an inch. Mercury indicates, by its height, pressure of water.

The columns of mercury are obviously substituted for

columns of water; which would have occupied tubes, had there been no interposition.

Water being gradually introduced; when mercury sinks to a level with mercury, water attains the level of water.

Into one of the tubes, containing columns of mercury, as above described, ether is introduced—into another, alcohol—and into the third, a solution of copper; until mercury, within them, is level with mercury without. Cupreous solution lower than surrounding water—alcohol higher—ether still more exceeds water in height.

INFERENCE.

Pursuant to the preceding experiments, the pressure of one fluid may be substituted for that of another; it being, however, necessary, that the heights of the respective fluids, be inversely as their gravities. It follows, therefore, that if, in lieu of water, the mercury were pressed by air, without the tube, unbalanced by air within, a column would be elevated proportionable to height and weight of the air.

INFERENCE VERIFIED, EXPERIMENTALLY.

Tube, closed at one end, is filled with mercury, and inverted—its lower orifice immersed in an adequate quantity of the metal.

Column, 30 inches in height nearly, remains in the tube, supported by pressure of surrounding air, and an index of its weight.

INFERENCE.

Base of mercurial column, thus supported, being equal to a square inch in area, would weigh fifteen pounds. Atmospheric pressure on every square inch in the earth's superficies, equally great, or equivalent to that of a mercurial stratum of the depth of thirty inches nearly.

ANOTHER DEMONSTRATION BY MEANS OF A TALL JAR, FULL OF WATER, AND A TUBE SHAPED LIKE A SHEPHERD'S CROOK.

OF THE WATER PUMP.

The admission of the atmosphere is necessary to the suction of the water from a receiver; *air* may be removed from *close* vessels by the same process. Water rises by pressure of the atmosphere. Air presses out by its own elasticity.

EXPERIMENTAL ILLUSTRATIONS.

Mechanism and action of the suction pump rendered evident by means of a model, with a glass chamber. Differ-

ence between pumping an elastic fluid, and a liquid, illustrated by an appropriate contrivance.

ACTION OF THE AIR PUMP SHOWN, BY MEANS OF GLASS CHAMBERS.

OF THE ELASTIC REACTION OF THE AIR.

Air is dependent on its own weight for its density, and enlarges its bulk in proportion as the space allotted to it is enlarged.

EXPERIMENTAL ILLUSTRATIONS.

Gum elastic bag closed, after being partly distended and placed in a receiver, from which the air is withdrawn, by the air pump—also a vessel nearly full of water inverted, its orifice being under water in a jar.

EXPERIMENTAL PROOFS, OF THE WEIGHT OF THE ATMOSPHERE.

Glasses for showing unresisted atmospheric pressure on the hand; on a bladder; on Otho Guericke's brass hemispheres.

Proof that the pressure arising from elasticity within, is equal to the pressure without.

Square bottle broken under receiver, by exhaustion of air from within, or from without.

The height of the column of mercury which balances the atmosphere, shown by exhaustion. Result compared with the Torricellian experiment.

USEFUL CHEMICAL IMPLEMENT FORMED BY MEANS OF A GUM-ELASTIC BAG AND A TUBE WITH A BULB.

PROCESS OF RESPIRATION.

The elevation of the sternum, rarefies the air in the cavity of the thorax. The atmospheric pressure, not being balanced, the air rushes through the trachea into the lungs, dilating all its cells. The depression of the sternum and diminution of the cavity, causes the air which had thus entered, or an equivalent portion, to flow out.

EXPERIMENTAL ILLUSTRATION.

From the open neck of a tall bell-glass, or receiver, a bladder is so suspended as to descend into it rather more than one-third of its height. The atmosphere has access to the cavity of the bladder, but not to the space between it and the internal surface of the receiver. Hence when

Hare's Hydrometer consists of a Frame supporting two tubes open at the bottom, but communicating at the top with a tube common to both, and to which is attached a Gum elastic bag — A vacuum being formed by the compression, and dilatation of this bag, water is made to ascend in one of the tubes, and the fluid to be tested in the other. — Their relative gravity is then indicated by a sliding scale which is divided into 2000 parts. — Thus water being made to stand at 1000, Alkohol will probably stand at 1750 &c —

this vessel is subjected to an alternate movement up and down, in water, the air alternately enters, and escapes from the bladder, as it passes into and out of the lungs in breathing.

RATIONALE.

Were not the bladder inflated, so as to compensate the enlargement of the space in which it is suspended, the air in that space would be in a state of rarefaction, inconsistent with an adequate resistance to the atmospheric pressure, acting against the internal surface of the bladder.

ADDITIONAL PROOF, THAT THE HEIGHTS OF FLUIDS ARE INVERSELY AS THEIR GRAVITIES, BY MEANS OF AN HYDROMETER CONTRIVED BY ME.

ON THE ALTITUDE OF THE ATMOSPHERE.

Supposing the atmosphere as dense above, as below, its height would be to that of the column of mercury which balances it, as the weight of air to the weight of mercury, inversely. Hence the height of mercurial column, (or 30 inches) multiplied by 11152 (=334560 inches, or 27880 feet) is the height which the atmosphere would have, if uniformly as dense as at the earth's surface. Density of the atmosphere being caused by its own weight, it has been demonstrated, geometrically, that, the heights being in arithmetical progression, densities will be in geometrical progression.

Thus, the density being, by observation,

at 3 miles			$\frac{1}{2}$	at 18 miles it will be			$\frac{1}{64}$
6	„	it will be	$\frac{1}{4}$	21	„	„	$\frac{1}{128}$
9	„	„	$\frac{1}{8}$	24	„	„	$\frac{1}{256}$
12	„	„	$\frac{1}{16}$	27	„	„	$\frac{1}{512}$
15	„	„	$\frac{1}{32}$	30	„	„	$\frac{1}{1024}$

or rarer than in the most perfect artificial vacuum.

ON THE MEASUREMENT OF HEIGHTS BY THE BAROMETER.

EXPERIMENTAL PROOF THAT ELASTIC FLUIDS ARE EXPANDED, EITHER BY REMOVAL OF PRESSURE, OR INCREASE OF HEAT.

A fluid excluded from a bulb, by a portion of air, either by heat, or by exhaustion of the surrounding air.

DEMONSTRATION, THAT ATMOSPHERIC PRESSURE OPPOSES, AND LIMITS, CHEMICAL ACTION, WHERE ELASTIC FLUIDS ARE TO BE GENERATED OR EVOLVED.

Water would boil at a lower temperature than 212° (F.), if the atmospheric pressure were lessened; for when it has ceased to boil in the open air, it will begin to boil again under a receiver exhausted by the air pump; and for every 530 feet of elevation, the boiling point is lowered one degree of Fahrenheit's thermometer.

Ebullition by cold, and by exhaustion, shown.

PROOF THAT SOME LIQUIDS WOULD ALWAYS BE AERIFORM, WERE IT NOT FOR THE PRESSURE OF THE ATMOSPHERE.

A flask, filled with mercury, excepting a small space occupied by ether, being inverted in a jar of mercury, under a receiver: on exhausting the air, the ether assumes the gaseous form, and excludes the mercury: on readmitting the air, the ether returns to its previous state, and the mercury re-occupies the vessel.

AS THE BOILING POINT OF LIQUIDS IS LOWERED BY A DIMINUTION OF PRESSURE, SO IS IT RAISED IF THE PRESSURE BE INCREASED.

Small strong glass flask, with narrow neck and smooth orifice. Small quantity of ether on the bottom heated till it boils: the orifice being closed by the finger, the ebullition is stopped: on the removal of the finger, it recommences with increased violence.

Very strong and close iron boiler containing water, with mercury at the bottom, a tube in the axis, and a thermometer on one side. Fire being applied, the mercury rises in the tube, from the increasing pressure of the steam, and in the thermometer, proportionably, from a corresponding elevation of the temperature.

WHY A JET OF HIGH STEAM DOES NOT SCALD, AT A DISTANCE AS GREAT AS MIGHT BE EXPECTED.

An admixture of air with aqueous particles, produces cold, as may be perceived when the wetted finger is held up to the wind. The quantity of such particles in high steam, is greater in proportion to the quantity of caloric, than in low steam; yet they are projected into the air, with greater violence, and of course are mingled with it more rapidly.

OF CONDENSATION.

CONDENSER EXHIBITED AND EXPLAINED.

PHENOMENA OF CONDENSATION, ILLUSTRATED EXPERIMENTALLY.

The bulk of air lessens as the pressure which it sustains augments; and the resistance arising from its elasticity, when confined, increases as the quantity is enlarged, or the confining space diminished.

Inflated bag, reduced in size, by exposure to air condensed within a receiver.

Inverted flask similarly exposed, its orifice under water. As condensation proceeds liquid rises into flask—when it occupies half the cavity, a column of mercury, exposed to same pressure, reaches same height, as that of mercurial column in the barometer.

Mercury being poured into a cylindrical jar, having no other aperture than the bore of a glass tube descending to its bottom, nearly; when the jar becomes half full of the metal, a column of it will be supported, at the same height, as in the previous experiment.

ON THE INFLUENCE OF PRESSURE ON THE ESCAPE OF GASEOUS SUBSTANCES FROM COMBINATION.

Sulphuric acid, in its action, on carbonates, and carbonic acid gas, in its union with water, are influenced by atmospheric pressure.

Carbonates and wood have been fused under great pressure without decomposition, and to this the production of bituminous coal, and some kinds of calcareous spar, has been ascribed by philosophers, who derive the existing structure, of the globe, from the action of fire.

EXPERIMENTAL ILLUSTRATION.

Effervescence of an acid with a carbonate, is lessened by the condenser, and increased by the air pump.

ON THE CHEMICAL AND MECHANICAL EFFECTS OF THE ATMOSPHERE.

Experimental proof, that the atmosphere, by its affinities, promotes evaporation while it retards it, by its weight.

Water frozen by boiling ether—also, by its evaporation.

THE MOST VOLATILE SUBSTANCES IN THE AIR, NOT ALWAYS THOSE WHOSE BOILING POINT IS LOW.

Instances:—

Oil of turpentine, camphor, petroleum, or naphtha.

ON THE STEAM ENGINE.

Principle of Savary's, illustrated by a matrass with a long neck.

Newcomen's
Watt's
High pressure } Engine.

GEOLOGICAL SPECULATIONS ON THE POSSIBLE CONSEQUENCES OF EXTRAORDINARY HEAT APPLIED TO OUR GLOBE.

COLD CONSEQUENT TO RAREFACTION.

Condensation in the receiver, on exhausting it, shown by means of the air pump. Also, by a small receiver with a gum elastic bottle, and a thermometer. Cold produced by the palm glass.

EXPANSION OF ELASTIC FLUIDS.

This is sufficiently intelligible from the experiments and observations already made. Their volume appears to be inversely as the pressure to which they are subjected, and directly as the heat.

SPECIFIC HEAT, AND THE CAPACITIES OF SUBSTANCES FOR HEAT.

The effects of equal weights of different substances, equally cool, (added successively to equal quantities of hot water, at the same degree of heat,) in lowering the temperature, will be found very different. Thus the effect of a given weight of water being 1000, the effect of a like weight of glass will be 137; of copper 114; of tin 60; and of lead 42; and if equal bulks be tried, the effect of copper, 1027, glass, 448, lead, 487, tin, 444. If equal weights of water and mercury at different temperatures be mixed, the effect on the water will be no greater, than if instead of the mercury, 1.28 of its weight of water had been added; and it takes twice as much mercury by measure, as of water heated to the same point, to have the same influence.

APPARATUS TO ILLUSTRATE CAPACITIES FOR HEAT.

The specific heat of bodies is, of course, always as their capacities for heat, or the comparative quantities of caloric which they contain when exposed to the same temperature externally.

ON THE COMMUNICATION OF HEAT.

ON SLOW COMMUNICATION—ON RADIATION.

ON SLOW COMMUNICATION.

CONDUCTING PROCESS. CIRCULATION.

ILLUSTRATION OF THE CONDUCTING PROCESS IN SOLIDS.

Hold one end of a brass pin in the fingers, the other in a candle flame.

ON INEQUALITY OF CONDUCTING POWER.

Effect of a pin compared with that of a splinter of wood, or a glass filament of the same size, by cementing them severally, at one end, to a stick of sealing wax, and heating them at their other ends.

The fracture of glass and porcelain, exposed to fire, is the consequence of an inferior conducting power; as the heat is not dis-

tributed with quickness enough to prevent inequality of expansion. Hence glass is less liable to crack by heat, in proportion as it is thinner.

It may be divided by a heated iron ring; or by a string steeped in oil of turpentine and inflamed; or by the heat generated by friction.

METALS BY FAR THE BEST CONDUCTORS.

Silver and copper are among the best conducting metals. Lead and platina among the worst.

CALORIC PROBABLY EXISTS IN METALS, AS AN ESSENTIAL CONSTITUENT.

ON THE PROCESS BY WHICH IT MAY BE CONDUCTED BY THEM.

ON THE CONDUCTING PROCESS, IN LIQUIDS.

PROOF THAT LIQUIDS ARE ALMOST DEVOID OF THE POWER TO CONDUCT HEAT.

Through a cork in the pipe of a glass funnel, nearly filled with water, pass the stem of an air thermometer, (bulb uppermost) till within about a fourth of an inch of the surface of the water. Over the water pour ether, and inflame it. The thermometer will not be affected by the heat of the flame, though sensible to a slight touch from the finger, even while under the water.

PROOF THAT HEAT MAY, IN SOME DEGREE, BE CONDUCTED BY LIQUIDS.

REFERENCE TO MURRAY'S EXPERIMENT WITH A VESSEL OF ICE.

PROCESS OF COMMUNICATING HEAT BY CIRCULATION.

A tall cylindrical jar of glass, with a stratum of water coloured red, in the upper part, colourless solution, in the middle, and a cupreous solution, below. Heat, being applied to the red stratum, does not cause its descent, but the stratum rendered blue, by the copper ascends, as soon as an accession of temperature is acquired from a heated ring, which is made to encircle the jar, in the vicinity of that stratum. The particles coloured blue, do not rise among those coloured red, because these were previously heated.

Water in glass vessel, with pieces of amber. Lamp applied. Circulation shown by the amber.

QUICK COMMUNICATION OF CALORIC, OR RADIATION.

The heat from a fire, received in opposition to the draught, as in roasting and toasting, is the effect of radiant caloric. A kettle placed over a fire, receives heat both by radiation, and the conducting process. Caloric proceeds in rays, or radii, from every

body warmer than the surrounding medium, and towards every one which is colder. Radiant heat is reflected by bright metallic surfaces, agreeably to the same laws as light, and may be collected in a focus, in a like manner.

The rays which come to a concave mirror, parallel to each other, proceed to its focus. Those emitted by a body in the focus, after meeting the mirror, proceed from it parallel to each other, and may be made to fall on another concave mirror, and concentrate themselves in its focus.

ILLUSTRATIONS.

Model for illustrating the operation of mirrors in collecting and transmitting radiant caloric.

Matrass with boiling water in one focus, affects a differential thermometer in the other. Phosphorus ignited at twenty, and even at sixty feet, by an incandescent cannon ball.

RADIATION OF COLD, SO CALLED.

Snow-ball placed near mirror, produces cold enough in the focus to be detected.

RATIONALE OF THE RADIATION OF COLD.

ON THE DIFFERENCE OF POWER, IN DIFFERENT SUBSTANCES, TO RADIATE, OR REFLECT HEAT.

BEST CONDUCTORS, WORST RADIATORS—AND VICE VERSA.

Cubical canister, having one side coated with charcoal, another with writing paper, a third with a pane of glass, the fourth uncovered: Effect of the charcoal on a thermometer in focus of mirror, as 100, of the paper as 98, of the glass as 90, while the effect of the metal only as 12.

Thus, metals which conduct best, radiate worst; and charcoal, which is one of the worst conductors, is the best radiator.

RATIONALE OF THE DIFFERENCE OF CONDUCTING POWER, AND RADIATING POWER, IN METALS, CHARCOAL, GLASS, POTTERY.

WORST RADIATORS, BEST REFLECTORS.

The same constitution which prevents radiation, causes reflection. When brass andirons are exposed from morning till night to a fire, so near as that the hand, placed on them, is scorched intolerably in a few seconds, they do not grow hot.

To preserve heat, in air, or to refrigerate, in water, vessels should be made of bright metal. Fire-places should be constructed of a form and materials to favour radiation: flues, of materials to favour the conducting process.

MEANS OF PRODUCING HEAT, OR RENDERING CALORIC SENSIBLE.

Solar beams. Lenses, mirrors. Burning of the Roman ships by Archimedes. Buffon's experiments.

ELECTRICITY.

Lightning. Electric spark.

ELECTROPHORUS.

Ignition by it exhibited.

GALVANISM.

Galvanic substitute for the electrophorus and deflagrator exhibited.

COLLISION, OR ATTRITION.

Flint and steel. Rotatory match box. Steel mill for light. Pieces of quartz rubbed. Metals heat in drilling or turning.

PERCUSSION.

A rod of iron rapidly hammered, ignites a sulphur match; and phosphorus, more easily. Coin grows hot when struck by the coining press; but, if repeatedly struck, and cooled at each succeeding stroke, it is less heated each time.

FRICTION.

Savages ignite wood by rubbing sticks together. Carriage wheels, by rapid motion, take fire.

Glass heated by friction, so as to separate into two parts, on immersing in water.

CONDENSATION.

Condenser for igniting spunk or tinder.

COMBINATION.

Boiling heat produced, by mixing sulphuric acid with water.

Combustion of platina with tin foil.

SOLUTION.

Solution produces either heat or cold, according to the nature of the substance dissolved, and solvent employed. Nitric acid grows warm, in acting on silver, or copper; and still more so on tin.

Water becomes cold, in dissolving nitre.

Sulphuric acid becomes boiling hot. and freezing cold, by successive additions of snow.

CHEMICAL COMBINATION, ATTENDED BY DECOMPOSITION.

Oil of turpentine ignited by nitric, and sulphuric acids.
Also by sulphuric acid, and chlorate of potash.
Alcohol inflamed by same means.
Tin foil ignited by nitrate of copper.

MECHANICAL ACTION, INDUCING CHEMICAL DECOMPOSITION.

A fulminating powder exploded by percussion.

METHODS OF SUPPORTING HEAT, FOR THE PURPOSES OF CHEMISTRY.

PRINCIPLE OF AIR FURNACES—OF ARGAND'S LAMP—AND OF THE FORGE FIRE.

Portable furnaces.
Cupelling furnace.
Small furnace with a drawer.
Lamp without flame.

BLOWPIPE.

Mouth blowpipe—*method of using it—great utility.*
Enameller's lamp.
Alcohol blowpipe.

COMPOUND BLOWPIPE.

Fusion and combustion of iron, steel, platina, copper, &c.

ON THE MEANS OF PRODUCING COLD, OR RENDERING CALORIC LATENT.

ON THE STATES IN WHICH CALORIC EXISTS IN NATURE.

ESSAY ON THE QUESTION WHETHER CALORIFIC REPULSION CAN BE DUE TO MOTION.

IMPORTANCE OF THE SUBJECT OF HEAT, OR CALORIC, TO THE PHYSIOLOGIST.

There is neither any body, nor any process, chemical or vital, in which its secret or obvious agency is not to be perceived or detected.

In no characteristics are chemical processes so analogous to those of life, as in their inseparable association with caloric, as a cause, or consequence.

Seeds and eggs, lie dormant till warmed.

CONCLUDING OBSERVATIONS, ON THE SUBJECT OF CALORIFIC REPULSION.

The ignition of spunk in the condenser is caused by the liberation of caloric from the air by compression — Dr. Hare cuts large vessels of glass by placing it in the crotch of a piece of wood, thus the legs of which the string runs, and is thus confined to one spot —

The sulp. acid and water are united ~~by~~ in a tall glass tube, in which is placed another narrow tube containing coloured water, which is thus made to boil — chlorate of potash and sulphuric acid, or alkohol mixtures with a large flame — In fulminating powders, the caloric exists as a component part, but escapes with violence, when a blow destroys the equipoise of the chemical affinities. —

ON LIGHT, OR THE MEDIUM OF SIGHT.

It must, necessarily, belong to Chemistry, to treat of light, so far as it is productive of heat, deoxydizement, or other chemical effects, and so far as it is evolved by chemical processes.

NATURE OF LIGHT.

According to Newton, and a majority of modern philosophers, it is a subtile fluid, which is either radiated, or reflected, from every visible point in the universe, in consequence of its elasticity, or the self-repellent power of its particles.

VELOCITY OF LIGHT.

It comes from the sun, about ninety millions of miles, in eight minutes, or nearly at the rate of two hundred thousand miles in a second.

INCONCEIVABLE MINUTENESS OF LIGHT.

The loss of weight in combustion, which can be ascribed to the escape of light, is inappreciable; yet enough is emitted by the flame of a candle, or lamp, to be perceived by many hundred millions of eyes. A sphere of rays is emitted from every visible point in the universe, in radius equal to the distance, at which that point is to be seen.

REFRACTION OF LIGHT.

When a ray of light passes obliquely, from a rarer into a denser medium, it is bent *towards* the perpendicular direction. When the course of the oblique ray is from the denser medium, into one which is rarer, it is bent *from* the perpendicular direction. The degree of the refraction, varies with the nature of the media causing it. It is greater in glass than in water—and in the diamond, greater than in either water or glass.

The rays of light, besides being thus refracted, sustain another change, called dispersion. Some of them being more, and some less refrangible than others, they are separated, and appear to be of various colours, as seen in the rainbow, or in the spectrum, artificially produced by a triangular prism of glass. The order of the colours, is red, orange, yellow, green, blue, indigo, and violet —beginning with the least refrangible rays, and ending with those which are most refrangible. The greatest heating power is found towards the red end of the spectrum—the highest illuminating power, about the middle, among the yellow and green rays—and the greatest deoxydizing power, among the violet rays. It is also ascertained, that beyond the red rays, there are invisible heat-producing rays—and beyond the violet, invisible rays, endowed with a deoxydizing power. It has been a question, whether the heating and deoxydizing power, might not exist in rays, severally destined for these purposes, and distinct from those which enable us to see.

POLARIZATION OF LIGHT—BY REFRACTION—BY REFLECTION.

ON THE SOURCES OF LIGHT.

THE SUN. COMBUSTION. ELECTRICITY. GALVANISM.

DECOMPOSITION, WITHOUT HEAT—*as in light wood.* LIFE—*as by the fire fly, or glow worm.*

ON THE EFFECTS OF LIGHT.

In the old bleaching process, by means of the solar rays, light is probably efficient, by promoting the transfer of oxygen, from water to the colouring matter, which it destroys. Certain vegetable leaves, if exposed to the sun in water, have been found to yield oxygen gas. Some metallic salts especially, and nitrate of silver, are blackened by a like exposure, owing, as is alleged, to deoxydizement. A mixture of hydrogen gas and chlorine gas, will, in the dark, remain for a long time, without combining; but, in the direct rays of the sun, will explode.

ON SPECIFIC GRAVITY.

A clear conception of it is necessary, to a comprehension of the language of the most useful sciences and arts. It may be defined, the ratio of the weight of a body, to its bulk.

ON THE MEANS OF ASCERTAINING SPECIFIC GRAVITIES.

All processes for this purpose, are reducible to two—ascertaining the weight of known bulk, or the bulk of known weight. When masses are reduced to the same bulk, it is only necessary to weigh them. When they are reduced to the same weight, it is only necessary to measure them. If water were among a number of substances reduced to the same bulk, and weighed, and its weight assumed as a unit, the numbers found would be the same as those now in use to express specific gravities. The gravity of water has been assumed as the standard weight, because this fluid may almost always be had, sufficiently pure; and the weight of bodies is easily compared with the weight of an equal bulk of it.

In order to obtain the specific gravity of a body, therefore, we have only to divide its weight, by the weight of a quantity of water equal to it in bulk.

The weight of a quantity of water, equal to the body in bulk, is equal to the resistance which the body encounters in sinking in water. Hence, if we can ascertain, in weight, what is necessary to overcome the resistance which a body encounters in sinking in water, and divide by this weight, thus ascertained, the weight of the body, we shall have its specific gravity.

In the case of a body which will sink of itself, the resistance to its sinking, is what it loses of its weight, when weighed in water.

In the case of a body which will not sink of itself, the resistance

to its sinking, is its weight added to the weight which must be used to make it sink.

PRACTICAL MEANS OF ASCERTAINING THE RESISTANCE TO A BODY'S SINKING IN WATER, EXHIBITED.

Scale beam.
Nicholson's hydrometer.
Steelyards by Lukens and Coates.
Sliding rod apparatus contrived by me.

TO ASCERTAIN THE GRAVITY OF A LIQUID.

Weigh a glass globe, of known weight, first in pure water, and then in the liquid. As the loss in the first instance, to the loss in the last, so is 1000, to the gravity sought. If the ball loses in water 1000 grs. the answer for any other fluid is the number of grains which it loses in that fluid.

Or, in a vessel which will hold 1000 grs. of water, at 60° (F.) weigh as much of any other fluid as will fill it. The weight in grs. is the gravity sought. In like manner may be found the gravity of substances, which are granular, or pulverulent.

ON HYDROMETERS, FOR ALCOHOL, AND FOR ACID, SALINE, AND OTHER SOLUTIONS. ALSO, FOR VEGETABLE INFUSIONS.

In these a constant weight is used, (to a certain extent,) and the differences of gravity are estimated, by the quantum of the stem immersed. In those instruments of this construction, where several weights are employed, the effect is the same, as if the stem of the instrument were lengthened as many times, as the number of the weights attached to it.

EXPERIMENTAL ILLUSTRATIONS.

Hydrometers and Saccharometers exhibited in operation; also my hydrostatic hydrometer as recently improved.

ON THE NECESSITY OF A STANDARD TEMPERATURE FOR HYDROMETRICAL OBSERVATIONS.

OF PNEUMATIC CHEMISTRY.

It appears from the phenomena of calorific repulsion, that solid ponderable matter, by combining with caloric, first expands, next melts, and finally passes into that elastic state of fluidity, in which the repulsive power so far predominates over the attractive, that the particles recede from each other as far as external pressure will permit. When a substance is naturally aëriform, it is called a gas: when it retains the form of air only in obedience to extraordinary heat, or in consequence of a removal of pressure, it is called a vapour.

The chemistry of gaseous substances, has been called Pneumatic Chemistry.

OF THE ORIGIN OF PNEUMATIC CHEMISTRY.

All gases were considered as common air, variously modified by impurities, until Dr. Black's discovery of carbonic acid gas. Priestley, incited by this to obtain air from other bodies, discovered oxygen gas, nitrogen gas, nitrous air, or nitric oxide, and various other aëriform substances. Cavendish, about the same time, distinguished hydrogen gas as a peculiar kind of air.

ON THE MODE OF COLLECTING, AND PRESERVING GASES IN THE PNEUMATO-CHEMICAL APPARATUS.

PNEUMATIC CISTERN CONTAINING WATER EXPLAINED; ALSO A PNEUMATIC CISTERN CONTAINING MERCURY.

Vessels are filled with water, or mercury, in a pneumatic cistern, and inverted as in the Torricellian experiment; then placed on a shelf, or part of the cistern, purposely kept, just below the surface of the water or mercury. Any gas emitted under the mouth of a vessel, so filled, and situated, rises and displaces the contained fluid.

OXYGEN GAS.

In the gaseous state, oxygen forms one-fifth of the atmosphere; and it pervades the creation, as a constituent of water, in the ratio of eight parts in nine. It is a principal, and universal constituent of animal and vegetable matter. Its combinations with metals, and various other combustibles, are of the highest importance in the arts. It was called oxygen, under the erroneous impression of its being the sole acidifying principle, from the Greek οξυς, acid—γινομαι, to generate.

ON THE MEANS OF PROCURING OXYGEN GAS.

It is yielded either by manganese, red lead, or nitre, when ex-

posed to a bright red heat in an iron bottle. There are various other means of obtaining oxygen gas. It is generally supposed, that in order to obtain it, in a high degree of purity, chlorate of potash must be employed; but I have found the first portions of the gas, from nitre, quite pure: and Dr. Thomson alleges, that this salt, by exposure to a carefully regulated heat, parts with one proportion of unadulterated oxygen.

PROPERTIES OF OXYGEN GAS.

It is insipid, inodorous, and per se incondensable, colourless, and transparent. It is but slightly absorbed by water; does not differ from common air in appearance, but is somewhat heavier, and it supports life and combustion, more actively. Under a bell glass filled with oxygen gas, an animal lives, and a candle burns, thrice as long as when similarly situated, with the same quantity of common air.

Oxygen gas is supposed to consist of oxygen, a simple or elementary substance, rendered aëriform by caloric.

It has been mentioned, (page 8) that chemical equivalents are usually assumed, so as either to make the representative of oxygen, or that of hydrogen, unity. The least combining proportions of these substances, as ascertained by the decomposition of water, being as one, to eight, if the equivalent of hydrogen be unity, that of oxygen will be eight; but if the equivalent of oxygen be unity, hydrogen will be represented by a decimal fraction of .125 As the numbers, now almost universally employed, are founded upon the equivalent of oxygen, as unity, I shall adopt this, as the standard in stating equivalents.

PROPERTIES OF OXYGEN GAS, ILLUSTRATED BY EXPERIMENTS.

Combustion of iron wire, charcoal, sulphur, and phosphorus, exhibited in large glass vessels of appropriate construction. Homberg's pyrophorus, being poured into it, flashes like gunpowder. Flame of caoutchouc, and other smoky flames, are rendered bright by surrounding them with this gas. An intense heat is produced in a lamp flame, urged by a jet of oxygen gas.

OF CHLORINE GAS.

As a gas, this substance exists only by artificial means; but as forming three-fifths of marine salt, it constitutes nearly one-fiftieth of the matter in the ocean; and is widely disseminated throughout the land, as well as the sea. It is also an ingredient in some of the most active agents, used in chemistry, or medicine. It was discovered by Scheele, and called by him dephlogisticated marine acid—afterwards oxymuriatic acid, by Lavoisier, and chemists generally, who adopted his nomenclature. Its present name was given by Sir H. Davy, from χλωρος, green—because its colour is greenish.

MEANS OF OBTAINING CHLORINE.

It is obtained by heating manganese, or red lead, and muriatic acid, in a glass or a leaden vessel:—or eight parts by weight of common salt, three parts of manganese, four parts of sulphuric acid, and four parts of water.

PROPERTIES OF CHLORINE GAS.

When pure and dry, it is a permanent gas, of a greenish yellow colour. When moist, it condenses at 40 degrees of Fahrenheit. Its weight to common air, is as two and a half to one, nearly. Even when existing in the air, in very small proportion, it is intolerable to the organs of respiration, and to respire it alone, would quickly produce the most fatal consequences.

That species of chemical action, which is attended by the phenomena of combustion, is supported by this gas with great energy. It has a curious property, first noticed by me, I believe, of exciting the sensation of warmth—though a thermometer, immersed in it, does not indicate that its temperature is greater than that of the adjoining medium. Probably it acts on the matter insensibly perspired. Chlorine is absorbed by water, and in the solution acts powerfully on metals. It appears to be the only solvent of gold. Chlorine and silver, exercise a more energetic affinity for each other, than for any other substances. Hence, they are reciprocally, the best tests. The compounds of chlorine with mercury, so useful in medicine, will be treated of, when on the subject of that metal. When the aqueous solution of chlorine, is exposed to the solar rays, it forms muriatic acid, with the hydrogen of the water, while the oxygen escapes. It bleaches, by liberating the oxygen of water, and thus enabling it to act on the colouring matter.

Chlorine gas was considered as a compound of muriatic acid and oxygen, and called oxymuriatic acid, till within about fifteen years. It is now, generally deemed an elementary substance, rendered gaseous by caloric. Oxygen being one, the chemical equivalent, or atomic weight, of chlorine is 4.5.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF CHLORINE.

Combustion exhibited, of metals in leaf, and in powder —of mercury in vapour—of phosphorus, by an appropriate contrivance. Water tinctured by litmus, rendered colourless, by merely falling through this gas. To two large vessels of clear water, soluble compounds of chlorine and silver are severally added—no change ensues, till the contents of both vessels are mingled in the third vessel, when a white cloud appears.

OF IODINE.

This substance, which has only been detected in certain plants, or their ashes, derives importance from its analogy with chlorine

and oxygen, especially the former. It was named Iodine, from ιοειδης, violet coloured.

OF THE MEANS OF OBTAINING IODINE.

It is obtained from the mother waters, of carbonate of soda manufactured from kelp. After all the soda, in a lixivium of kelp, has been crystallized, the residuum is concentrated, and distilled with sulphuric acid, in a retort: the iodine passes over, and condenses in shining crystals of an intense purple, or black colour.

OF THE PROPERTIES OF IODINE.

When solid it is of a bluish black colour—friable—acrid—and almost insoluble. It transiently stains the skin yellow. It fuses at 225° (F.)—volatilizes at 350° in a most beautiful violet vapour. It is considered as an element.

Iodine is incombustible either in oxygen, or atmospheric air; but forms acids severally with oxygen, hydrogen, and chlorine, called oxiodic, or iodic—chloriodic—hydriodic acids. In its habitudes with the Voltaic pile, it is more electro-negative, than any other matter, excepting oxygen, chlorine, and probably fluorine. With starch or fecula, iodine produces an intense blue colour; so that these substances are reciprocally tests for each other. The equivalent (or atomic weight) of iodine, is 15.5.

EXPERIMENTAL ILLUSTRATIONS.

A glass sphere, containing iodine, on being warmed, appears filled with a violet coloured vapour.

To a large glass vessel, containing some boiled starch diffused in water, a small quantity of iodine being added, the fluid becomes intensely blue.

OF THE NOMENCLATURE OF THE COMPOUNDS OF CHLORINE, OXYGEN, AND IODINE.

Agreeably to the nomenclature proposed by the celebrated Lavoisier, and his coadjutors, and generally adopted by chemists; when oxygen, in combining, does not acidify, the resulting combinations are called oxides. Hence, by analogy, the compounds of chlorine with other substances, when not acidified by it, are called chlorides; those of iodine, iodides.

OF NITROGEN GAS, OR AZOTE.

Nitrogen gas forms nearly four-fifths of the atmosphere. Its ponderable base is a principal element, in animal substances. In vegetables, it is only occasionally found. It was called azote, from the Greek ζωη, life, and α, privative of; but as other gases were found no less worthy of this distinction, the name of nitrogen was given to it, because it produces nitric acid.

MEANS OF OBTAINING NITROGEN GAS.

It may be procured by any substance which will, in a close ves-

sel, abstract oxygen from the included portion of the atmosphere; —as, for instance,—by the combustion of phosphorus;—by iron filings and sulphur moistened:—by nitrous gas.

OF THE PROPERTIES OR CHARACTERISTICS OF NITROGEN GAS.

As a gas, it is distinguished by a comparative want of properties. It is lighter than oxygen gas, or atmospheric air. It does not support life or combustion, but is, obviously, a harmless ingredient in the air. It is incondensable, per se, and seems, in many instances, to carry its caloric into combination, being a constituent of a majority of the most explosive compounds.

Nitrogen has been suspected, by some chemists, of being a compound substance, but is generally considered as an element. Its compounds with oxygen, hydrogen, chlorine, carbon, &c., will be treated of hereafter. The equivalent, or atomic weight, of nitrogen, is 1.75.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF NITROGEN.

After phosphorus is burnt out in a close vessel, the residual air is transferred to a convenient bottle. A candle flame introduced into the bottle, is extinguished.

ATMOSPHERIC AIR,

Is a mixture (not a chemical compound) of oxygen gas, and nitrogen gas, with some moisture, and carbonic acid.

The properties of this compound gas, are such as might be anticipated from those of its constituents. Its active qualities are those of oxygen, but enfeebled by dilution with the other inert ingredients.

EUDIOMETRY.

DIFFERENT EUDIOMETERS EXHIBITED.

Simple graduated tube. Hope's Eudiometer. Henry's modification of Hope's Eudiometer. Volta's Eudiometer. Various eudiometrical instruments contrived by me.

OF HYDROGEN GAS.

In its gaseous state, it is the principal constituent of all ordinary flame. Its ponderable base, combined or associated with oxygen, or carbon, or both, is found in water, and all vegetable and animal substances. It derives its name from ὑδωρ, water, and γεινομαι, to produce.

MEANS OF PROCURING HYDROGEN GAS.

It may be obtained by the reaction of diluted sulphuric, or muriatic acid, with zinc, or iron; or of steam with iron turnings, made red hot in a gun barrel:—also, by means of potassium. It may be evolved from water by galvanic agency, and is then purest.

ON THE PROPERTIES OF HYDROGEN GAS.

It is the lightest of all known substances. A cubic inch weighs only about a fiftieth of a grain. It is about 200,000 times lighter than mercury, and 300,000 times lighter than platina. In its ordinary state, it smells unpleasantly. When pure, it is alleged to be without odour. It is perfectly incondensable per se. Its capacity for heat is very high. It does not support life, but is not very injurious to it. In consequence of its levity, it escapes rapidly from an open vessel, unless inverted. It is the most inflammable of all substances, yet extinguishes a taper when immersed in it. A jet of it ignited, appears like a candle flame, feebly luminous: and if surrounded by a glass tube, produces a remarkable sound. Subjected to the electric spark, when mixed with oxygen, or atmospheric air, it explodes. The oxygen may be esteemed equal to one-third of the deficit caused by the explosion: hence, by this process, air may be analysed. The ponderable base of hydrogen gas forms water, with oxygen; muriatic acid, with chlorine; hydriodic acid, with iodine; ammonia, with nitrogen; and prussic acid, with cyanogen. It combines also with carbon—with sulphur—and with phosphorus. When pure, its flame is but feebly luminous.

Hydrogen gas is considered as an elementary substance, so attractive of caloric as that, per se, it cannot be separated from it. The equivalent, or atomic weight, of hydrogen is .125.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF HYDROGEN GAS.

Its evolution from a phial, (with a capillary tube well fitted to the neck) exhibited; and the jet ignited. A glass retort, with diluted acid and zinc, employed, to show the extrication of this gas, and mode of catching it in bell glasses over the cistern. Self-regulating reservoir of hydrogen gas, in glass, exhibited,—likewise a self-regulating reservoir, in lead. A candle flame extinguished, and rekindled, by means of a phial, filled with hydrogen. Hydrogen ignited by an electrophorus—by galvanic ignition—and by platina sponge:—also exploded with atmospheric air, or with oxygen gas, by a taper,—a calorimotor,—by electricity. A glass balloon being balanced on a scale beam, hydrogen is made to displace the air. The balloon rises, because the hydrogen is lighter than air. Change produced in the weight of a globe, by exhausting it and filling it with hydrogen.

EXPERIMENTS WITH THE COMPOUND BLOWPIPE—PYROTECHNY BY MEANS OF HYDROGEN.

WATER

Is produced by the combustion of hydrogen gas, with oxygen gas. It may be decomposed by passing it in steam, over iron ignited, in a gun barrel: by the aid of acids: by electricity: by galvanism: by the alkaline metals: by sulphurets, phosphurets, and vegetable leaves. Water is vaporizable by heat, and evaporable by means of its attraction to the air. A certain proportion of moisture, in the air, is necessary to health and comfort.

The equivalent of oxygen being	1.
And that of hydrogen	0.125
Water is represented by	1.125

ON SOME PECULIAR AND IMPORTANT AGENCIES, OR CHARACTERISTICS, OF WATER.

Water is necessary to some crystals.—It appears necessary to acidity—to alkalinity—and to galvanic processes. The powers of water, as a solvent, are peculiarly extensive, and are increased by heat and pressure. It seems to be a substance, sui generis, isolated from oxides, acids, and alkalies. It unites with, and becomes solid in, the earths and alkalies: and produces heat during combination with them. The compounds resulting, are called hydrates.

EXPERIMENTAL ILLUSTRATIONS OF THE AGENCY OF WATER.

Tartaric acid and bicarbonated alkali, pulverised, and mixed. The addition of water produces effervescence. Nitrate of copper rolled up in tinfoil has no action till moistened—ignition then ensues. Sulphuric acid added to zinc in powder: the addition of water produces a violent action. Heat produced by caustic earths, or alkalies with water.

EXPERIMENTAL DEMONSTRATION, OF THE COMPOSITION OF WATER.

Water, recomposed by combustion of hydrogen, emitted in a jet within a large glass vessel. Also, by successive explosions by means of galvanic ignition. Decomposed by a galvanic apparatus, and its gaseous elements evolved:—these are exploded by the spark, and reduced again to the aqueous form.—Decomposed by sulphuret, and phosphuret of lime, and potassium.

MEANS OF DETECTING, OR MEASURING HUMIDITY IN THE AIR.

OF HYGROMETERS.

On hygrometers by evaporation. On the hygrometer by means of an organic sensibility to moisture, in the beard of a wild oat. Of Daniel's hygrometer. Hygrometers contrived by me.

ON THE THEORIES OF COMBUSTION.

Stahl supposed the existence, in all combustibles, of a common principle of inflammability; which he called phlogiston, from phlogizo, to burn. He inferred that all substances, in burning, give out phlogiston. The fallacy of this hypothesis is evident, since metals become heavier during combustion, obviously in consequence of the absorption of oxygen from the atmosphere. According to the advocates of the phlogistic theory, nitrogen was confounded with carbonic acid, and carbon with hydrogen, because both carbon and hydrogen, were supposed to consist of phlogiston, nearly pure; and oxygen, in combining with them, was supposed to become phlogisticated air; the name then given to nitrogen gas. It is now well known, that with carbon, oxygen forms carbonic acid,—with hydrogen, water; and that nitrogen gas, contains neither carbon, nor hydrogen.

Sulphuric, and phosphoric acids, and metallic oxides, were severally supposed to be ingredients, in the sulphur, the phosphorus, or the metals, producing them: thus the compounds were assumed to be lighter, and to be contained by one of their constituents! Lavoisier's theory was correct, in suggesting, that in all ordinary cases of combustion, oxygen is absorbed. It was erroneous, in not providing for exceptions, as, when metals enter into combustion, with sulphur, or with chlorine.

Combustion, according to common sense, is an intense state of corpuscular reaction, accompanied by an evolution of heat and light.

It is the general law of nature, that the capacities for caloric, of compounds, are sometimes greater, sometimes less, than that of their constituents. Hence chemical combination, is sometimes productive of heat, sometimes of cold.

There is a mysterious and reciprocal dependency, between chemical reaction, galvanism, electricity, and magnetism, which must be explained, before the phenomena of combustion can be well understood.

The heat of combustion appears to be principally due to the gaseous agent; the light, to what is called the combustible.

The idea of a class of supporters of combustion, and of combustibles, has no other foundation, than that certain substances are more frequently agents in it, and therefore called supporters. Thus, hydrogen will only produce fire, with oxygen and chlorine; sulphur, with metals;—and carbon, with oxygen; but as oxygen or chlorine, will burn with a great variety of substances, they are called supporters of combustion, and the substances with which they combine, during combustion, are called combustibles. Iodine is classed among the supporters also, because it combines with almost all the substances with which they unite, and forms analogous compounds. Iodine is not gaseous, however, and, upon the whole.

is as analogous to sulphur as to chlorine.—The propriety is questionable, of taking it into the class of supporters, and excluding sulphur.

Sulphur is intermediate, in its habitudes, between phosphorus and iodine. The habitudes of selenium, a newly discovered substance, seem to lie between the metals and sulphur. Hydrogen, phosphorus, carbon, boron, and silicon, deserve as well to be called combustibles, as oxygen, chlorine, and iodine, to be called supporters: but these appellations are evidently commutable, according to circumstances; since a jet of oxygen, fired in hydrogen, is productive of a flame similar to the inflamed jet of hydrogen, in oxygen. If we breathed in an atmosphere of hydrogen gas, oxygen gas would be considered as inflammable, and, of course, as a combustible.

THEORY OF VOLUMES.

It has been advanced by Gay Lussac, that substances, when aëriform, unite in volumes which are equal; or that the larger volume, is double, triple, or quadruple, of the other. This doctrine is well supported by facts.

It has been extended, by inference, to all bodies, under the idea, that all are susceptible of the aëriform state. A volume, is said to be the equivalent of another volume, when capable of forming with it a definite compound, or when just adequate to displace it from combination. This theory is not inconsistent with the atomic theory, if the number of atoms in any one equivalent volume, be to those in any other, so, that the lesser, may divide the larger, without a fraction.

Instances, supporting the doctrine of volumes:—

Water consists of	1 volume of	Oxygen and	2	Hydrogen gas.
Ammonia	1	Nitrogen	3	Hydrogen.
Carbonic acid	1	Oxygen	2	Carbonous oxide.
Sulphuric acid	1	Oxygen	2	Sulphurous acid.
Muriatic acid	1	Chlorine	1	Hydrogen.
Muriate of ammonia	1	Ammonia	1	Muriatic acid.
Sub-carbonate of ammonia	1	Ammonia	1	Carbonic acid.
Bicarbonate of ammonia	1	Ammonia	2	Carbonic acid.
Nitrous gas	1	Nitrogen	1	Oxygen.

It is in truth well ascertained, that equal volumes, or multiples of them, are naturally equivalents of the substances of which they are constituted. Thus supposing a volume of oxygen gas to weigh

1000 grains, and that a like volume of every other aëriform matter were weighed, it would appear that numbers expressing the weights of the volumes in grains, would either be the same, as those which represent their atoms, or chemical equivalents; or might be rendered the same, by multiplying them, by two, or by four.

It must be evident that numbers which represent the weights of like volumes are in the same ratio to each other as those which are employed to represent their specific gravities, and would in fact be the very same numbers, were oxygen gas assumed as the standard, instead of atmospheric air.

ON THE ALKALIES.

Alkali is a word supposed to be derived from the Arabic. Until of late, only three alkalies were known—potash, soda, and ammonia. The two former being difficult to vaporise, have been called fixed alkalies: the latter, being naturally aëriform, has been called the volatile alkali. A new mineral fixed alkali has been discovered lately, and named Lithia. It is procured from a stone called Petalite. Hence, its name from the Greek, λιθος, a stone. Alkalies have also been recently detected among vegetable principles; of which I shall treat in my lectures, on vegetable chemistry.

OF POTASH—SODA.

MEANS OF OBTAINING POTASH—SODA.

Potash is obtained by the lixiviation of the ashes of inland plants, especially wood. The ley, thus procured, boiled down, forms potashes of commerce. Potashes, ignited, lixiviated, and evaporated to dryness, form pearlash. Pearlash, dissolved, boiled with quick-lime, filtered, and boiled down to the consistency of moist sugar, redissolved in alcohol, and boiled down gradually; and lastly, fused at a red heat in a silver vessel, yields the potash of chemists. Evaporation being stopped, as soon as the alcohol has escaped, crystals are obtained. After fusion at a red heat, it contains about 20 parts of water, of which it cannot be deprived, per se, by heat. It is therefore called a hydrate.

Soda is obtained from the ashes of certain plants which grow on the sea shore, as potash is, by the incineration of those which grow inland:—also from muriate of soda, and from sulphate of potash.

Soda is purified, and procured in the state of hydrate, or in crystals, by the process, above described, for its kindred alkali.

PROPERTIES OF POTASH AND SODA.

Potash and soda, in common with other alkalies, have a peculiar alkaline taste: they render tincture of turmeric, brown; syrup of violets, green; and alkanet, blue. Colours, changed by acids, are restored by them. They are the opposites of, and antidotes to

acids, forming with them compounds, neither acid nor alkaline. They are incorrectly said to render vegetable blues green, as if this were universally true. Alkanet is made blue by them, while neither litmus, nor indigo, are made green.

Potash is much more deliquescent than soda; though its salts are less soluble. Both cauterize the flesh. Potash is most active. Lapis infernalis, or common caustic, is an impure hydrate of this alkali.

Potash is distinguished from soda, by forming a less soluble salt with tartaric acid, and giving a precipitate with muriate of platina. Subjected to galvanic action, both alkalies are decomposed into oxygen gas, and metallic bases, called potassium and sodium.

COMPOSITION OF POTASH—SODA.

Potash and soda are respectively oxides of potassium and sodium, metals, which derive their names from these alkalies.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF POTASH AND SODA.

Infusions of alkanet, of turmeric, of red cabbage, and of litmus, (reddened by an acid,) are poured into large glasses: a drop of potash being added to each, the alkanet becomes blue, the turmeric brown, the red cabbage green, while the litmus regains its colour. To strong solutions of potash and soda, or their carbonates, a strong solution of tartaric acid being added in excess, the potash only yields crystals. Into different salts of the two alkalies in solution, muriate of platina is poured: a light yellowish precipitate, distinguishes the potash.

OF SOAP.

OF SOFT SOAP, OR SOAP OF POTASH, AND HARD SOAP, OR SOAP OF SODA. RATIONALE OF THE DETERSIVE PROPERTIES OF SOAP.

OF LITHIA, THE NEWLY DISCOVERED MINERAL ALKALI.

Pure lithia is less soluble than soda or potash, in water or alcohol. Its carbonate is less soluble in water. Its muriate is soluble in alcohol, and its phosphate insoluble in water.

OF POTASSIUM.

MEANS OF OBTAINING POTASSIUM.

It was discovered by Sir H. Davy, by means of the Voltaic pile, and of course may be thus procured; but the following method, contrived by Gay Lussac, enables the chemist to obtain it in larger quantities. A luted gun-barrel is filled with iron wire, or turnings, and ignited in a blast furnace, as highly as possible. Hydrate of potash is passed in at one end, so as to fuse and run over the iron, which arrests its oxygen. The potassium meanwhile volatilizes, and condenses at the other end of the barrel, just be-

yond where it is red hot. There is great uncertainty in this process, from the difficulty of getting the luting to stand the requisite heat, without which, the gun-barrel soon burns. I have substituted for the luting, a very thick cylinder of iron, which renders the process certain.

PROPERTIES OF POTASSIUM.

It appears, and cuts like lead, only softer; yet it is so light as to swim in water. It fuses at 150° (F.). It decomposes water, regenerating potash, and evolving inflamed potassuretted hydrogen, upon the water, and even upon ice. Its avidity for oxygen is preeminently great. When heated in oxygen gas, in excess, an oxide is formed, containing double the quantity of oxygen found in potash. If hydrate of potash be applied to a thick plate of iron, in a state of combustion, the rosy flame of potassuretted hydrogen demonstrates, that a decomposition ensues. The same result obtained by pouring the fused hydrate upon iron card teeth, heated to combustion in a crucible.

EQUIVALENTS OF POTASSIUM, POTASH, AND ITS HYDRATE.

The atom of potassium, equivalent	5.
with 1 atom oxygen, equivalent	1.
forms 1 atom potash, equivalent	6.
and with 1 atom water, equivalent	1.125
constitutes 1 atom hydrate, equivalent	7.125

OF SODIUM.

MEANS OF OBTAINING, AND PROPERTIES OF, SODIUM.

The analogy between this metal and potassium, is quite as great, as between potash and soda.

Sodium is obtained by the same process as potassium. It is less energetic, than potassium, in its action. It does not fuse so easily, as it requires 200° (F.). It decomposes water, evolving hydrogen, but without inflammation.

EQUIVALENTS OF SODIUM, SODA, AND ITS HYDRATE.

The atom of soda, equivalent	3.
with 1 atom of oxygen, equivalent	1.
forms 1 atom of potash, equivalent	4.
which with 1 atom of water, equivalent	1.125
constitutes 1 atom hydrate, equivalent	5.125

EXPERIMENTAL ILLUSTRATIONS.

The inflammation of potassium upon water, and ice, exhibited,—and regeneration of the alkali, in the water em-

ployed, demonstrated by the usual tests: also, the decomposition of potash, by iron or card teeth, heated intensely.

OF AMMONIA, OR THE VOLATILE ALKALI.

It is named from sal ammoniac, the salt which yields it.

MEANS OF OBTAINING AMMONIA.

Sal ammoniac, in powder, being mixed with powdered quicklime, or caustic fixed alkali, ammonia is evolved in the state of a gas, which may be collected over mercury. Heat is requisite to complete the process.

PROPERTIES OF AMMONIA.

Ammonia acts like an alkali, upon the organs of taste, upon vegetable colours, and in neutralizing acidity. To the smell it is agreeably stimulating, when very much diluted with the air. In any considerable proportion, it is intolerable to the eyes, and organs of respiration. It enlarges, and then extinguishes, a candle flame; yet explodes with oxygen or chlorine. Its weight, to common air, is as 3 to 5—100 cubic inches weigh 18 grs. Water absorbs it with surprising velocity; and will hold from 450, to 670 times its bulk. Ice melts in ammonia, quicker than in fire. Heat either decomposes, or volatilizes, all ammoniacal compounds; and either of the fixed alkalies, or of the three more powerful alkaline earths, disengage it from any of the acids.

COMPOSITION AND ATOMIC WEIGHT OF AMMONIA.

Ammonia consists of one atom or one volume of nitrogen	1.75
And three atoms or three volumes of hydrogen . . .	.375
Its atomic weight is therefore	2.125

The four volumes, of which it consists, are condensed into two.

EXPERIMENTAL ILLUSTRATIONS.

In a cavity, made in a bit of muriate of ammonia, a moistened globule of mercury is supported, in communication with one of the poles of a Voltaic pile. The mercury is made to communicate with the other pole. The metal swells rapidly, and assumes all the characteristics of an amalgam.

INFERENCE.

It would be anomalous for an amalgam, to arise from a union of mercury with any substance not metallic. It may therefore be inferred, that ammonia is a gaseous alloy of hydrogen and nitrogen—that these, if obtained in the solid state, would be metalloidal in their characteristics.

those stones of a soapy nature, owe their
peculiarity to magnesia

ILLUSTRATIONS RESUMED.

Sal ammoniac, and quick-lime, being powdered and mixed in small glasses, pungent fumes are emitted. The same mixture contained in Florence flasks, being exposed to a chafing dish of coals, the ammonia is extricated, and collected in bell glasses, over mercury. The introduction of a few drops of water, causes the gas to disappear. Ice, in the same way introduced, is liquefied, and causes a like result. Water, tinctured by turmeric, alkanet, &c., changed as by other alkalies.

Evolution of gas shown, by means of potash and an ammoniacal salt introduced into a glass vessel over mercury.

A mixture of ammonia, with oxygen gas, exploded in a hydro-oxygen eudiometer.

Other illustrations are deferred, until muriatic and carbonic acids are treated of.

OF EARTHS.

The substances classed under this head, are the principal ingredients in the congeries, called earth, in common language; and which, until lately, was considered one of the four only elements of the creation. The earth of flints, or of sand, is one of these substances, and the most abundant. It is exhibited, in purity, in rock crystal, and is called silex, or silica.

The earth, to which clay owes its plastic property, is named alumine, by chemists; because it is obtained in purity from alum. Next to silex, it abounds most in the globe.

With respect to abundancy, lime has the next grade to alumine; and magnesia ranks next to lime; though it may be questionable, whether the quantity of this earth, in the structure of our planet, exceed that of iron, or carbon.

The remainder of the substances recognised, under the generic appellation of earths, are unknown to the mass of mankind, and independently of chemical research, had escaped human observation. These are the barytes, strontites, glucine, zircon, yttria, and thorina, of chemists.

The earths are divided into earths proper, and alkaline earths.

OF THE ALKALINE EARTHS.

The alkaline earths are, barytes, strontites, lime, and magnesia.

OF THE PROPERTIES OF THE ALKALINE EARTHS.

They are thus designated, because they are alkaline in taste and

in their effects on vegetable colours; and because, like the alkalies, they lose their causticity, by a union with carbonic acid. All are more or less soluble; but magnesia the least so; barytes and strontites, form glass with silex; and with water hydrates, indecomposable by heat. The order in which they are alkaline, beginning with that which is most so, is as follows: barytes, strontites, lime, and magnesia.

COMPOSITION OF THE EARTHS.

The *alkaline* earths hold a middle place between the old metallic oxides, and those of potassium and sodium. The earths, *proper*, are generally inferred to be metallic oxides. To me, it seems more likely, that they form a class of bodies intermediate, between carbon, boron, and the metalloids; or passing from one, into the other. This view of the analogy between carbon, and the bases of alumine, and silex, is very much strengthened by the discovery, in these, of a property, heretofore supposed peculiar to carbon, of forming steel by combining with iron.

OF BARYTES.

This earth was named from the Greek, Βαρυς, (heavy,) because the minerals containing it are peculiarly heavy, when compared with other earthy substances.

OF THE MEANS OF OBTAINING BARYTES.

Carbonate of barytes, or the sulphuret, (obtained by igniting sulphate of barytes intensely with charcoal) is to be exposed to the action of nitric acid, in a quantity sufficient to saturate it. The solution must be filtered, and evaporated, and then deprived of water by an intense heat, in a platina, or porcelain crucible.

Like the carbonates of potash and soda, those of barytes and strontites, cannot be decomposed, per se, by heat. The addition of carbonaceous matter, enables us to decompose them, as it changes the carbonic acid to gaseous oxide of carbon, which has no affinity for the earths, and therefore escapes.

OF THE PROPERTIES OF BARYTES.

It is acrid—slakes like lime, and is more caustic and more soluble in water. It is gray at first, but absorbs water and becomes white. Its aqueous solution is rendered milky by carbonic acid, and by combining with the same principle, becomes covered with a pellicle of carbonate, when exposed to the atmosphere. From its solution in boiling water, barytes crystallizes, on cooling. Ignited intensely, and exposed to a current of oxygen gas, it absorbs the oxygen, and passes to the state of deutoxide. Its solutions are the best tests for sulphuric acid, and reciprocally, sulphuric acid is the best test for barytes. This earth is poisonous.

COMPOSITION OF BARYTES.

A paste made of carbonate of barytes, is placed upon a platina tray, communicating with the positive pole of a Voltaic series.

1 The charcoal unites with the oxygen of the sulphuric acid

2 Baryta dissolves with difficulty in water; heat aids it much, but does not aid lime (a remarkable exception)

Those earths have a common property of precipitation by carbonic acid — once proposed to keep water in this way —

Alkalis boiled with lime are not altogether free from car. acid.

Baryta water the best test for sulphuric acid

Charcoal decomposes the sulphates, tho' Lime will not –

1 Strontites obtained by the ignition of the pure nitrate.

2 The Strontitic salts are not poisonous, as the Barytic are except the sulphat

A hollow being formed in the paste, a globule of mercury is introduced into it, and made to communicate by a wire with the other voltaic pole. The mercury is converted into an amalgam, which by distillation in a glass tube, yields a metallic substance of a dark gray colour, with a lustre inferior to that of cast iron, which fuses below a red heat, and is susceptible of volatilization, and of acting upon the glass recipient, if sufficiently heated.

To this metal, or metalloid, the name of barium has been given.

The equivalent of barium is - - - - - -	8.75
Hence, as barytes is a protoxide of barium, and consists of an atom of the metal, with one atom of oxygen, equivalent to - - - - - - - -	1.00
The equivalent of barytes is - - - - - -	9.75

EXPERIMENTAL ILLUSTRATIONS.

Barytes, free from water, exhibited: also in crystals. Barytic water rendered milky by the carbonic acid of the breath, blown into it by means of a tube. Solutions of barytes, or of sulphuric acid, introduced into distinct vessels of pure water, have no effect; but portions mingled, in the same vessel, produce a cloud. Water, coloured by alkanet, turmeric, &c. changed by barytes, as in the case of the alkalies.

STRONTITES.

It is as analogous to barytes, as potash to soda, in its properties and composition. It is distinguished from barytes, by the red colour which its solutions communicate to flame—by its crystallization—by its being more soluble in boiling water, and less so in cold.

COMPOSITION.

Strontites is a protoxide of strontium, a metalloid obtained by Sir H. Davy, by the process already described, in the case of barium, excepting that the native carbonate of strontites, was substituted for the carbonate of barytes.

The equivalent of strontium is - - - - -	5.5
Hence, as it forms strontites, with one atom of oxygen, equivalent to - - - - - - - - -	1.0
The equivalent of this earth must be - - - - -	6.5

EXPERIMENTAL ILLUSTRATIONS.

Turmeric—alkanet—and red cabbage, changed by strontitic water, as by alkalies.

Red colour of inflamed alcohol, containing strontites, shown.

ON LIME.

ON THE MEANS OF OBTAINING LIME.

This earth may be procured from oyster shells, or white marble, by calcination.

ON THE PROPERTIES OF LIME.

Lime is less alkaline, than the preceding earths. Its carbonate does not retain its water and acid, when heated intensely.

Quicklime is pure lime, or limestone deprived of its water and acid. When moistened it grows very hot and falls into powder, which is called slaking. The earth absorbs, and causes the consolidation of, the moisture, which is consequently abandoned by the caloric, to which water is indebted for its fluidity.*

Water takes up about $\frac{1}{700}$ of its weight, of this earth, forming lime water. On this, a pellicle arises, as in the case of barytes, soon after exposure to the air, by the union of the lime with the carbonic acid, which always exists in the atmosphere. Though lime is precipitated by carbonic acid, in the state of carbonate, water, impregnated with this acid, dissolves the carbonate—hence limestone water. Oxalic acid is the best test for lime. This earth was first fused by me.

COMPOSITION.

By a process analogous to that employed in the case of barytes, and strontites, a paste made of pure lime, or its sulphate, yields with mercury an amalgam. From this, in one instance only, Sir H. Davy succeeded in obtaining calcium by volatilizing the mercury from it, in a glass tube: but even, on that occasion, the tube was destroyed so as to prevent a satisfactory examination. The colour of calcium appeared to be silver white.

Lime is inferred to consist of one atom of calcium, equivalent to - - - - - - -	2.5
And one atom of oxygen - - - - -	1.0
Hence the equivalent of the earth is - - -	3.5

EXPERIMENTAL ILLUSTRATIONS.

A glass of lime water, is not made turbid, by air from a bellows, but becomes so on propelling the breath through it. Carbonic acid in bells, and bottles:—absorption of it, shown. Lime precipitated from solutions, of its muriate, or nitrate, by sulphuric, or oxalic acids.

OF MORTAR.

* See page 10.

1 Found as a carbonate in marble, chalk limestone &c - also in shells & coral
To obtain lime absolutely pure, dissolve lime in muriatic acid, add a little amm.
- filter, & precipitate by carb. amm.
2 Sul. acid poured on muriat. lime causes the whole to congeal into a solid mass of sul. lime
Sul. lime when crystallised is called Selenite; when fibrous & earthy, Gypsum; when granular or massive Alabaster
The most celebrated marbles are those of Paros, of Mons Pentelicus near Athens, of Carrara, of Sienna, of Derbyshire &c &c
The Derbyshire spar, or Blue John is a Fluate of Lime

Glass tubes are formed by drawing ~~&~~ ~~drawing~~ globes; glass that are heated

1 Only found water at Hoboken R.I.

— A pint of Sea Water affords

Common Salt	grs 180.5
Sum. Magnesia	23
Sul. Magnesia	15.5
Sul. lime	7.1
	Grs. 226.1

— Sul. Mag. obtained from bitter water

— Soap stone, talc, asbestos &c contain Magnesia

2 Fluric acid is the only one that acts energetically

— In making Glass, the oxide of Lead is used to increase its fusibility, refractive powers, tenacious nesp, capacity of bearing vicissitudes & transparency

— It makes it more liable to crack

Boracic acid used in making gems but too expensive for glass

OF MAGNESIA.

MEANS OF OBTAINING MAGNESIA.

This earth may be precipitated by potash, or soda, from a solution of Epsom salts.

OF THE PROPERTIES OF MAGNESIA.

Magnesia is nearly insoluble in pure water, but dissolves to a considerable extent in water, containing carbonic acid, forming a bicarbonate, or soluble magnesia. The affusion of concentrated sulphuric acid, on calcined magnesia, produces great heat, and even ignition.

Magnesia is distinguished from the other alkaline earths, not only by being less energetic, in its affinities and alkaline properties, but by the solubility of its sulphate.

Lime and magnesia are among the most fixed, and refractory substances in nature: and were deemed infusible, until I operated upon them, with the compound blowpipe.

COMPOSITION.

The analysis of magnesia, rests on the same basis as that of lime; an amalgam having been obtained from it, in the same way; but not the metal from the amalgam, to a satisfactory extent.

Magnesia is a protoxide of magnesium, the metalloid, which amalgamates with the mercury in the process just alluded to.

The atom of magnesium, is inferred to have for its equivalent - - - - - - - - -	1.5
And as it constitutes magnesia, with one atom of oxygen	1.
The equivalent of this earth must be - - -	2.5

EXPERIMENTAL ILLUSTRATIONS.

Its precipitation from a solution of Epsom salts, exhibited. Also, discolouration of alkanet, and of turmeric.

OF EARTHS PROPER.

OF SILEX, OR SILICA.

MEANS OF OBTAINING SILEX.

Quartz being powdered, and fused with double the weight of pearlash, and lixiviated; a liquor silicum results: from which, when poured into an acid, the earth separates. Thus obtained, it is slightly contaminated by potash. Fluoric acid, by its action on glass, or flints, takes up silex, or its base, and, according to Brande, deposites it in a state of sub-fluate, on meeting with water.

ON THE PROPERTIES OF SILEX.

Pure silex is white—tasteless—inodorous—and insoluble. It was deemed infusible, until fused by me in 1802. It does not co-

here when wetted. In powder, it is acted on by alkaline solutions. Glass consists of silex, united with about one half its weight of fixed alkali. The proportions are those, of the liquor silicum inverted, in which the quantity of alkali is double that of the earth.

COMPOSITION.

Silex, or silica, is a compound of oxygen, with a peculiar substance, which by many chemists is classed among the metals, and called silicium. By others, it is classed, more reasonably as I think, with carbon, and boron; and is called silicon. Silex is remarkable for having the attributes of an acid, so far as respects the highly characteristic property of combining energetically with alkalies, whilst for acids it has scarcely any affinity. It is, however, far more deficient of solubility, in water, than any other acid.

Agreeably to the arduous investigations of Dr. Thomson, the atomic weight, or equivalent, of silex, is 2.

OF GLASS. OF THE ANNEALING PROCESS.

EXPERIMENTAL ILLUSTRATIONS.

Silicate of potash—a soluble glass—exhibited:—also the solution of it, called liquor silicum, which is made to precipitate its silex, by means of an acid.

Prince Rupert's drops exploded, by a slight fracture—a glass tube breaks in pieces, in consequence of being scratched with a file.

OF ALUMINE, OR THE PURE EARTH OF ALUM.

OF THE MEANS OF OBTAINING ALUMINE.

It is found pure in the gems called by jewellers oriental, and classed by Brogniart under the head of Corindon Telesie. The ruby, sapphire, amethyst, and topaz, of the most beautiful kinds, are thus designated. They have the highest specific gravity of stony minerals, and are only inferior to the diamond in hardness. Differing from each other, only in colour, they yield by analysis little else than pure alumine. There are other jewels of the same name and colour, which ought not to be confounded with those here alluded to.

Alumine is obtained sufficiently pure, by potash, from a solution of alum.

OF THE PROPERTIES OF ALUMINE.

It is inodorous, insipid, and infusible in the furnace. It is plastic when moistened—soluble in alkalies and acids—and combines with colouring matters, forming the precipitates called lakes. It is the only earth which was fused, before the compound blowpipe was

invented. Its property of contracting and hardening by heat, was noticed, when on the subject of Wedgwood's pyrometer.*

In consequence of experiments, analogous to those mentioned in the case of magnesia and lime, it has been inferred that alumine is a protoxide, consisting of one atom of a metalloid, called aluminum, and one atom of oxygen.

As 1.25 has been deduced as the equivalent of aluminum, to this adding the equivalent, of one atom of oxygen, we have 2.25 for the equivalent of the earth.

EXPERIMENTAL ILLUSTRATION.

A solution of alum precipitated by an alkali.

OF ZIRCON, GLUCINE, YTTRIA, THORINA.

As they are objects merely of scientific curiosity, attention to their details would be injudicious, until other knowledge be acquired.

OF ACIDITY.

Acidity was originally synonymous with sourness—but all the substances now called acids, are not sour. They generally make vegetable blues red; yet sulphurous acid whitens litmus, and indigo is not reddened by any acid. Acids always neutralize alkalies, and restore colours destroyed by them. Acids do not combine with acids—nor alkalies with alkalies,—but acids and alkalies unite energetically with each other. Acids are generally soluble in water. Silex furnishes an exception. The idea of a universal acid principle, commenced with Paracelsus,—was supported by Beecher and Stahl, and afterwards by Lavoisier;—but it was questioned by Berthollet.

The existence of a common cause, not only of acidity, but of alkalinity, still, to me, appears probable.

It will be shown hereafter, that if any light bodies, be electrified, either by glass or resin, they will separate: but that if one, be electrified by glass, and the other by resin, they will attract each other.

The cause of galvanic phenomena has been supposed by many great philosophers, to be the same as that of electricity produced by glass, or resin; but modified by some unknown cause, so as to act between atoms, instead of masses.

The pole, or end of a galvanic or voltaic series, terminating with the most oxidable metal, has been found to show a very feeble electrical excitement, of the same kind as that produced by glass;—while the other termination of the galvanic series, displays the opposite excitement, of resin.

Agreeably to a very extensive experience, it would seem, that of any two substances in nature, simultaneously exposed to wires.

* See page 11.

severally proceeding from the different poles of a galvanic series, —one will go to the positive, the other to the negative pole. Atoms are inferred to be in electrical states, different from the poles to which they are severally attracted: and are said to be electro-negative, when attracted by the positive pole—and electro-positive, when attracted by the negative pole. Oxygen is conceived to be more invariably attracted by the positive pole, than any other substance. Next to oxygen, chlorine is most electro-negative:—and iodine next to chlorine. Other substances, as for instance, metalloids, and metals,—also hydrogen, carbon, sulphur, and phosphorus, are comparatively electro-positive. Substances, of the two opposite classes, in combining with each other, constitute particles, which are either electro-positive, or electro-negative, accordingly as the different energies of their ingredients preponderate. Thus, in alkalies, consisting of oxygen united with metalloids, the electro-negative character of the metalloids predominates; but the reverse is true, of acids consisting of the same electro-negative principle, oxygen, in combination either with sulphur, nitrogen, phosphorus, carbon, boron, or other substances, of an electro-positive character.

At a mean point, between the extremes, at which oxygen and the alkaline metalloids are placed, there are substances, whose relation to the pile is equivocal, or wavering; and it should be understood, that this relation is always comparative. Chlorine is electro-positive with oxygen, and electro-negative with every other body. Iodine is electro-positive, either with chlorine, or oxygen, and, with other substances, electro-negative.

I avail myself of the language, which has arisen from the hypothesis by which these polarities are ascribed to electricity, though I do not think their existence thus adequately accounted for.

I suspect, that alkalinity, and acidity, and these galvanic polarities, have a common cause, perhaps in some appropriate combinations of the imponderable, but material, causes of heat, light, and electricity. To other combinations of these imponderable principles, the sweetness of sugar, the pungency of mustard, or of pepper, and the activity of certain vegetable poisons, may be due. It is known that in morphia, and strychnia, and in certain vegetable acids, the acid, and alkaline properties, are adventitious, being attached to elements, which exist in other compounds, without inducing acidity, or alkalinity.

ON THE NOMENCLATURE OF ACIDS, AND THEIR SALTS.

Where substances form by a union with oxygen, two oxides, or two acids—one containing a larger—the other a lesser proportion; —the acid, or oxide, having the lesser proportion, is distinguished by the name of the substance oxygenated, and a termination in *ous*:—that containing the larger proportion of oxygen is designated in the same way, substituting *ic* for *ous*—as sulphurous acid, and sulphuric acid—nitrous and nitric oxide, or acid—carbonic

In glass making, the manganese is used to destroy the tinge of green — the purple colour it causes is destroyed by charcoal — Arsenic also used as a Flux

Glass is coloured by the various oxides

White Enamel is Glass made opaque by the oxide of Tin

Amethyst, Aventurine, Hyacinths of Compostella, Flint, Onyx, Chalcedony Carnelian, Sardonyx, Opal &c are all silicates

acid, carbonous oxide.* Acids, of which the names terminate in *ous*, have their salts distinguished by a termination in *ite*. Acids, of which the names end in *ic*, have their salts distinguished by a termination in *ate*. Thus, we have nitrites, and nitrates—sulphites, and sulphates. If there be a third acid, having still more oxygen, the letters *oxy* are prefixed. If the alkali be in excess, the word *sub* is prefixed; as sub-sulphate. If the acid be in excess, *super* is prefixed, as super-sulphate. The letters *bi* are placed before the name of salts having a double proportion: hence carbonate, and bi-carbonate.

OF CERTAIN ELEMENTARY SUBSTANCES,

CALLED ACIDIFIABLE, AND THEIR ACID AND OTHER COMBINATIONS.

ON CARBON, OR CHARCOAL.

Nature presents us with the most beautiful, and purest specimens of this substance. The diamond is pure carbon. When equal weights of charcoal and diamond are severally exposed to the rays of a powerful lens, in oxygen gas, included in different bell glasses, they are both converted into carbonic acid. In like manner, when diamond powder is heated with nitre, or iron, the effects are analogous to those which would arise from charcoal.

Carbon is very abundant in nature, in the various kinds of fossil coal; from anthracite, in which it is nearly pure and unallied with bitumen, to the highly bituminous variety called candle, or cannel coal. In bituminous coal, there is much hydrogen. Carbon pervades vegetable, and animal matter, as an essential element. It is, especially, a constituent of the fibres of wood.

OF THE METHODS OF OBTAINING CHARCOAL.

In the laboratory, charcoal is obtained, sufficiently pure, by intensely heating wood in close vessels: in the large way, by igniting large quantities of wood, so covered with earth, that the access of air may at first be controlled, and afterwards prevented.

OF THE PROPERTIES OF CARBON.

It is usually black, inodorous, and insipid. Charcoal of wood is one of the best radiators, and worst conductors, of heat. There is reason for believing this peculiarity to result from its excessive porosity; as in the form of anthracite, carbon conducts heat better, and probably radiates it worse.† Charcoal is highly susceptible of galvanic ignition.

With *abundance* of oxygen, carbon produces carbonic acid—with an *inadequate supply*, carbonous oxide. Carbon combines

* This practice, as respects oxides, has only extended to the instances here given. Carbon yields only one oxide and one acid, hence there is no carbonic oxide, nor carbonous acid.

† Lehigh coal is the species called, by mineralogists, anthracite.

also with hydrogen, sulphur, and nitrogen; and, as lately ascertained, with chlorine; with which, however, it cannot be made to enter into combustion, even by the intense ignition of the voltaic pile.

The atomic weight, or equivalent of carbon, is .75.

OF THE HIGHLY INGENIOUS EXPERIMENTS, AND OBSERVATIONS ON THE VOLATILIZATION OF CARBON, BETWEEN THE POLES OF THE GALVANIC DEFLAGRATOR, BY PROFESSOR SILLIMAN.

OF CARBONIC ACID GAS.

This gas constitutes about a hundredth part of the atmosphere, so that lime-water cannot be exposed to it, without becoming covered with a pellicle of carbonate of lime. Carbonic acid is an incessant product of combustion, and of the respiration of animals. It is a principal ingredient in marble and limestone.

ON THE PRODUCTION OF CARBONIC ACID, BY COMBUSTION:—BY CALCINING CARBONATES:—BY ACIDS:—BY FERMENTATION:—BY RESPIRATION.

ON THE PROPERTIES OF CARBONIC ACID.

It causes precipitates in lime, barytic and strontitic waters, or in a solution of acetate of lead. It destroys life, and extinguishes flame. It is salubrious to breathe, when diluted with atmospheric air; and however it may be concentrated in water, is innocent in the *stomach*. Potassium burns in it. It may be absorbed by water, but is evolved from it unchanged, either by rarefaction, ebullition, or frost. It reddens litmus. It combines with earths and alkalies, forming carbonates. It is very antiseptic. Plants probably absorb it, retain its carbon, and give out its oxygen. The respiration of animals, tends to compensate this change, by carbonizing the oxygen of the air. Under very great pressure it becomes a liquid.

COMPOSITION.

Carbonic acid consists of one volume, or one atom of carbon, equivalent to - - - - - - -	0.75
And two atoms, or one volume of oxygen, equivalent to	2.00
Hence the equivalent of the acid is - - - -	2.75

EXPERIMENTAL ILLUSTRATIONS.

Evolution of the gas shown—also, its property of extinguishing a candle.—Its difference from nitrogen, rendered evident by means of lime-water. Litmus, reddened by carbonated water—colour restored by boiling.

Analysis of mixtures, containing the gas, by means of the sliding rod eudiometer, with lime-water.

Under a common temperature water takes up its own volume – under a pressure of two atmospheres twice its volume & so on. —

8 As car. lime is soluble in car. acid, on escape of the gas, in its solution in water takes up the precipitate formed. –

Car. acid is converted into car. oxide when it takes an additional quantity of its base oxi seen in burning charcoal, in Lehigh Co

Iron at a red heat decomposes car. acid. – Carb. acid, and ammonia unite & condense into a solid – 1. vol of 1st to 2 of the 2d

+ 2 vols of carbonic acid. and 1 of oxygen detonate, & 2 vols. of carbonic acid result.

° Here the filings subtract a portion of the oxygen from the carbonic acid, & leave carbonous oxide

Being generated in a vessel having apertures at different heights, it escapes through the lowest of them, which may be open; or when all of them are shut, overflows the brim like a liquid.

These characteristics made evident, by means of an appropriate apparatus, and of the yellow fume which accompanies the gas, when extricated from carbonate of ammonia, by deep orange coloured nitric acid.

OF IMPREGNATING APPARATUS.

EXPERIMENTAL ILLUSTRATIONS.

Woulfe's and Pepy's apparatus, shown: also, my substitutes for Woulfe's, and my apparatus for regulating the supply by absorption.

ON THE MEANS EMPLOYED IN MANUFACTURE OF ARTIFICIAL MINERAL WATERS.

OF CARBONOUS OXIDE.

MEANS OF OBTAINING CARBONOUS OXIDE.

It may be obtained by calcining whiting with iron filings, in a gun-barrel, at a white heat.

PROPERTIES OF CARBONOUS OXIDE.

It is a gas highly deleterious to life, and incapable of supporting combustion. Even when diluted with air, it is pernicious, as it is to this we must ascribe the noxious influence of burning charcoal.

COMPOSITION.

Carbonous oxide is supposed to contain one atom, or a half a volume of oxygen less than carbonic acid; of course its equivalent must be 1.75.

EXPERIMENTAL ILLUSTRATIONS.

Carbonous oxide gas evolved by process abovementioned, and collected in bell glasses over water—Combustion, and detonation of it shown, and its consequent absorption by lime-water.

OF THE GASEOUS COMBINATIONS OF CARBON WITH HYDROGEN.

It is these varieties of inflammable gas, that constitute the inflammable matter of our culinary fires, and of the flames of candles, lamps, and gas-lights.

Carbon and hydrogen are in the opposite extremes, as respects their susceptibility of the aëriform state. Carbon is probably, per se, more difficult of volatilization by heat, than any other substance in nature. Hydrogen, on the other hand, as far as our experience goes, is not susceptible of condensation, even into the non-elastic state of fluidity. There is, however, a powerful affinity between these substances; and hence, when a compound, which contains

them, is subjected to heat, they are made to combine in various proportions, according to the intensity of the ignition, and the influence exercised by the nitrogen, or oxygen, which may have been associated with them in the compound, from which they are evolved.

Until of late, only two varieties of carburetted hydrogen were recognised: carburetted, and bi-carburetted, or super-carburetted, hydrogen—also called olefiant gas, from its forming an etherial oil when mixed with chlorine gas.

Dr. Thomson, in his late work upon the principles of chemistry, alleges the existence of the following compounds of hydrogen and carbon.

The first consists of—one volume of carbon vapour, and one volume of hydrogen condensed into one volume specific gravity .4861, atmospheric air being 1. One volume of this gas requires, for its combustion, $1\frac{1}{2}$ volumes oxygen.

The second, is the gas usually called olefiant—which consists of two volumes of carbon vapour, and two of hydrogen gas condensed into one volume. Its specific gravity is 0.9722. It requires, for its combustion, three volumes of oxygen gas, with which it produces two volumes of carbonic acid.

The third consists of three volumes carbon vapour, and three of hydrogen gas condensed into one volume. Its specific gravity is 1.4583. It requires $4\frac{1}{2}$ volumes of oxygen for its complete combustion, and the residual gas is three volumes of carbonic acid gas. Pursuant to the observations of Mr. Dalton, the oil gas employed in gas-lighting, is principally of this kind.

The fourth compound consists of four volumes of carbon vapour, and four volumes of hydrogen condensed into one volume. Its specific gravity is 1.9444. It requires six times its weight of oxygen for its complete combustion; and a volume, thus burnt, leaves four volumes of carbonic acid as a residue. Combined with one volume of aqueous vapour, this gaseous substance constitutes the vapour of sulphuric ether; which consists of one volume of quadro-carburetted hydrogen = specific gravity 1.9444
and one volume of the vapour of water, of specific gravity of .6250

And hence the specific gravity of the etherial vapour is 2.5694

A fifth species, of carburetted hydrogen, is alleged to consist of six volumes of carbon vapour, and six volumes hydrogen gas condensed into one volume: its specific gravity being 2.9166. It requires nine times its volume of oxygen gas to consume it thoroughly, and leaves, as a residue, six volumes of carbonic acid gas. Of this kind, the vapour of naphtha from coal is alleged to be.

Another crystalline compound, of carbon and hydrogen, has been noticed, called naphthaline; composed of one and a half atoms carbon, and one atom hydrogen.

The best kind of coal to obtain this gas is that the most bituminous, & contains the least sulphur

In London the cost of a lamp fed by gas, giving a light equal to 7 candles is 3 farthings per hour – Sperm. oil 3 d. – moulds candles 3½ d. wax candles 1½ d

MEANS OF OBTAINING THE GASEOUS COMPOUNDS OF CARBON AND HYDROGEN.

By the destructive distillation of bituminous coal, wood, oil, tar, and other inflammable substances, the various forms of carburetted hydrogen are obtained.

Olefiant gas is obtained, purest, by passing alcohol through an ignited porcelain tube; or, by distilling one part alcohol, with four parts of sulphuric acid. The first kind is alleged to be evolved, purest, from the mud of stagnant waters in summer. The fire damps, so destructive to miners, is a species of carburetted hydrogen.

The illuminating power of these various forms of gas, seems to be, in proportion to the quantity of carbon condensed into a volume; provided there be oxygen enough to consume it: but, otherwise, the excess of carbon, renders the flame smoky. Hence the greater brilliancy of small flames, or those excited by a current of air; as in the Argand lamp.

The same flame which in common air is unpleasantly fuliginous, transferred to oxygen gas, displays an uncontaminated brilliancy.

EXPERIMENTAL ILLUSTRATIONS.

Corks, cotton seed, caoutchouc, nuts, introduced in small quantities into a gun-barrel, of which the but has been heated to a bright red heat. Brilliant jet of flame proceeds from the touch-hole. Inflammation of gas extricated by distillation from bituminous coal, or oil. Also of olefiant gas. Carburetted hydrogen gas, mixed with oxygen gas, and exploded in a sliding rod eudiometer. Residue renders lime-water milky.

PROFESSOR OLMSTEAD'S METHOD BY COTTON SEED.

WHY MOISTURE CAUSES SOME MINERAL COALS TO BURN BETTER.

ON MOREY'S WATER-BURNER.

ON THE SAFETY LAMP.

EXPERIMENTAL ILLUSTRATIONS.

The efficacy of the safety lamp, in preventing explosions, experimentally shown, by enveloping it, while burning, in hydrogen gas. The flame seems to go out, but on the re-admission of the air, is seen to resuscitate.

OF CHLORINE WITH OLEFIANT GAS.

OF CHLORINE WITH OLEFIANT GAS—ALSO WITH CARBON.

Olefiant gas received its name, from its condensing with chlorine gas, into a liquid of an oleaginous consistency. On exposure to

chlorine gas and the solar rays, this liquid yields a perchloride of carbon; which by passing over quartz, in an ignited glass tube, yields a protochloride. A sub-chloride of carbon has also been accidentally produced.

OF CARBURET OF NITROGEN, OR CYANOGEN.

ON THE MEANS OF OBTAINING CYANOGEN.

Distil prussiate of mercury, in a coated glass tube, at a heat as nearly approaching to redness, as the glass will bear. The tube must have a smaller one adapted to it, to convey the gas under the bells, in the mercurial pneumatic cistern.

PROPERTIES AND COMPOSITION OF CYANOGEN.

It is a true gas. It is characterized by burning with a beautiful violet flame. It is nearly twice as heavy as common air. Water absorbs four and a half volumes—pure alcohol, twenty-three volumes. One hundred parts of it, detonated with oxygen, produce 200 parts of carbonic acid, and 100 parts of nitrogen. It is absorbed by alkalies, and alkaline earths. With hydrogen, it forms prussic, or hydrocyanic acid. In relation to the galvanic poles, it is electro-negative. An instance is thus afforded of the adventitious character of this species of polarity—since carbon and nitrogen, the elements of cyanogen, are both electro-positive.

Cyanogen consists of two volumes of carbon vapour, and one of nitrogen, condensed into one volume. Hence as the volumes, of these gases, are equivalent exactly to their atomic weights, the composition of cyanogen must be two atoms carbon, equivalent to 75×2= . - - - - - - - 1.50
And one atom of nitrogen, equivalent to - - - - 1.75

Hence the equivalent of cyanogen is - - - - 3.25

EXPERIMENTAL ILLUSTRATIONS.

The gas evolved agreeably to the process abovementioned, and its flame exhibited. Also mixed with oxygen gas and exploded.

ON SULPHUR.

It is a well known mineral production, sold in the shops, in rolls, under the name of brimstone—also in flowers. It is found pure in the vicinity of volcanoes, of which it is a product. In combination with metals, it is widely disseminated. From some of these, called pyrites, it is sublimed, in flowers, by heat.

PROPERTIES OF SULPHUR.

It is insipid, and inodorous, unless when burning—electric by friction—cracks from the warmth of the hand. At 180° (F.) it evaporates slowly, yielding an inflammable solution in air—melts at 225°—thickens between 350° and 400°—sublimes at 600° in flow-

ers, which appear crystalline when viewed by the microscope. Its purity may be proved by its total evaporation from platina leaf. It is soluble in boiling oil of turpentine. It combines with metals, earths, and alkalies, forming sulphurets. An acid precipitates it from solutions of alkaline, or earthy sulphurets. It forms with oxygen, the sulphurous and the sulphuric acids. Other combinations are alleged to exist. The weights of oxygen, and sulphur, in sulphurous acid, are equal. In sulphuric acid, there is one half more oxygen. Sulphur combines with hydrogen gas, in two proportions, forming sulphuretted, and super, or bi-sulphuretted hydrogen.

The atomic equivalent of sulphur is	2.
With one atom of oxygen it forms hyposulphurous acid, equivalent	3.
With two atoms of oxygen it forms sulphurous acid, equivalent	4.
With three atoms of oxygen it forms sulphuric acid, equivalent	5.
With one atom of hydrogen it forms sulphuretted hydrogen, equivalent	2.125
Two atoms sulphur, with one hydrogen, forms bi-sulphuretted hydrogen, equivalent	4.125

EXPERIMENTAL ILLUSTRATIONS.

The combustion of sulphur with common air and oxygen gas, exhibited by means of appropriate apparatus.

The combustion of Dutch gold leaf by sulphur—also, combustion of an iron bar, and iron wire, shown.

OF SULPHURIC ACID.

MEANS OF OBTAINING SULPHURIC ACID.

This acid is obtained, by burning sulphur and nitre, in leaden chambers, or by the old process of distilling copperas, or green vitriol; whence the almost obsolete name, oil of vitriol. It is best purified by distillation.

PROPERTIES OF SULPHURIC ACID.

It is a gas, when uncombined with water; but this absorbs so much of it, as to double its specific gravity nearly. Its aqueous solution is oleaginous in its consistency—caustic, when concentrated—intensely acid, when dilute.—It heats greatly, when mixed with water, especially when to 73 parts of acid, 27 parts of water are added. Hot water explodes with it as with a melted metal. Its strength is reduced by the absorption of moisture, when exposed to the air.

EXPERIMENTAL ILLUSTRATIONS, OF THE PROPERTIES, AND THE MEANS OF PRODUCING, SULPHURIC ACID.

The production of sulphuric acid, shown in a large glass globe. Its effects, upon litmus—barytes—metals—and organic products, displayed: also, in heating water.

Water frozen, when placed over a broad vessel containing this acid, under an exhausted receiver.

Poured upon snow, it is at first heated almost boiling hot; but if more snow be added, becomes freezing cold.

OF SULPHUROUS ACID.

MEANS OF OBTAINING SULPHUROUS ACID.

It is formed, when sulphur is burned under ordinary circumstances: or, by boiling sulphuric acid on sulphur, mercury, and other substances, by which it may be partially deoxidized.

PROPERTIES OF SULPHUROUS ACID.

It is a gas, intolerable to the organs of respiration, deleterious to life, and incapable of supporting combustion. Water takes up 33 times its bulk. Unlike other acids, it whitens litmus—bleaches silk and wool. It is decomposed by substances, which attract oxygen more powerfully than sulphur. When, on the other hand, oxygen is presented to it freely;—by absorbing this principle, it passes into the state of sulphuric acid.

EXPERIMENTAL ILLUSTRATIONS.

Fumes of burning sulphur, drawn through water. Effect of the water, thus impregnated with sulphurous acid, upon litmus.

OF SULPHATES, OR SALTS, FORMED BY SULPHURIC ACID WITH THE EARTHS, ALKALIES, AND OTHER OXIDES.

Their solutions, all yield precipitates with solutions of barytes. Heated with charcoal, they are converted into sulphurets, which, if moistened, smell like rotten eggs.

OF SULPHITES.

Sulphites are rarely met with. They are known by having the smell (especially when heated) of sulphurous acid gas. They pass, when in solution, or moistened, to the state of sulphates.

OF SULPHURETS.

MEANS OF OBTAINING SULPHURETS.

Sulphurets of the earths, or fixed alkalies, are obtained by fusing, or boiling them with sulphur. When formed in the moist way, they are contaminated by sulphuretted hydrogen, which (water being present) is always evolved by them.—Sulphuret of ammonia

Salzkur – sp. pa. 1.990

is obtained by distilling at a gentle heat, one part of quick-lime, one part of muriate of ammonia, and half a part of sulphur.

OF THE PROPERTIES OF SULPHURETS.

When moistened, they smell like rotten eggs, or the washings of a gun barrel.—They change vegetable colours like alkalies—blacken the skin—and are decomposed by acids, yielding sulphur in a white precipitate. They absorb oxygen, and are, therefore, used in eudiometry. They are erroneously said, to effervesce violently with acids.

EXPERIMENTAL ILLUSTRATIONS.

Sulphurets exhibited, and their solutions, from which, by the addition of an acid, sulphur precipitates in a white powder.

Air, confined over a solution of sulphuret of lime, parts with its oxygen to the sulphur, generating a pellicle of sulphate of lime.

OF SULPHURETTED HYDROGEN GAS.

MEANS OF OBTAINING SULPHURETTED HYDROGEN.

This is most easily obtained from sulphuret of iron, by diluted sulphuric acid.

OF THE PROPERTIES OF SULPHURETTED HYDROGEN.

It is a permanent gas, with the odour, as already described, of rotten eggs, absorbable by water, inflammable, and explosive, forming, by combustion, with air or oxygen gas, water, and a mixture of sulphurous and sulphuric acids. It tarnishes metals; especially preparations of lead, of which it is a test, and by which it may be detected. It is evolved from privies—blackening the ceruse, or carbonate of lead in paint. Its aqueous solution reddens litmus: combines with earths and alkalies, forming hydrosulphurets, and has, therefore, some attributes of acidity. It is found in native mineral waters. It is decomposed by various substances, having affinity for one or both of its constituents—as, for instance, by chlorine—potassium—sodium—sulphurous acid—ignited carbon—and by successive electric explosions. Sulphuretted hydrogen decomposes all metallic solutions, unless those of iron, nickel, cobalt, manganese, titanium, and molybdena, in consequence of the attraction between hydrogen and oxygen, or chlorine; and between sulphur and the metals. Atmospheric air, is said to be rendered deleterious to life, by the addition of $\frac{1}{250}$ of this gas.

EXPERIMENTAL ILLUSTRATIONS.

Method of extricating sulphuretted hydrogen gas exhibited—also, the impregnation of water with it. Effects of its aqueous solution on litmus—and on various metallic solu-

tions. Characters written, with dissolved acetate of lead, are blackened by exposure to the gas, or its aqueous solution.

ON HYDRO-SULPHURETS.

MEANS OF OBTAINING HYDRO-SULPHURETS.

They are obtained by saturating with the gas, as it is generated, alkalies, and earths, dissolved, or suspended in water. The apparatus, for impregnating carbonates, may be used for this purpose.

PROPERTIES.

Hydro-sulphurets all form colourless solutions in water, are changed to a greenish hue by time, and blacken the bottle, by deoxydizing the lead, in the glass. An acid discharges the sulphuretted hydrogen, by combining with the base. The hydro-sulphurets precipitate all metallic solutions; the solvent being attracted by the base, and the metal and oxygen by the sulphur and hydrogen. In analyses for metallic poisons, the hydro-sulphurets are of course useful.

EXPERIMENTAL ILLUSTRATIONS.

Production of hydro-sulphurets, shown—also, their effects on metallic solutions.

OF SULPHURETTED HYDRO-SULPHURETS.

They are said to exist always in solutions of sulphurets; and differ from simple hydro-sulphurets, only, in containing a double proportion of sulphur.

METALLIC SULPHURETS.

They are treated of, under the head of their metals.

SULPHURET OF CARBON.

It is obtained, by passing sulphur, in vapour, over pieces of charcoal, intensely ignited, in a porcelain tube.

PROPERTIES OF SULPHURET OF CARBON.

It is colourless and transparent—acrid—pungent to the taste—caustic—somewhat aromatic—smells nauseously, and is very inflammable, volatile, and difficult to freeze.

COMBINATIONS OF NITROGEN WITH OXYGEN.

OF NITRIC ACID.

It has already been mentioned, that with about a hundredth part of carbonic acid, and some aqueous vapour, nitrogen and oxygen, in a state of mixture, (not of combination,) constitute the atmosphere. Nevertheless, when in due proportion, subjected to a succession of electric sparks, they combine, and form nitric acid, one of the most active and important agents of chemistry. There is

some other unknown mode, in which a chemical union is induced between these atmospheric ingredients, whence the great quantity of nitrate of potash, found in nature.

MEANS OF OBTAINING NITRIC ACID.

The production of nitric acid, by electricity, is too laborious to be resorted to, for the purpose of the chemist. Possibly lightning might be made to produce it. The mode, usually employed, is to pulverise and distil nitre with one-half its weight of the strongest sulphuric acid, in glass, porcelain, or iron vessels.

PROPERTIES AND COMPOSITION OF NITRIC ACID.

It is nearly one-half heavier than water—usually, orange-coloured—when pure, colourless. It cannot be obtained free from water. It acts powerfully on almost all the metals,—also on organic substances, causing them to be oxydized. It stains and destroys the skin. It may be considered as the matter of atmospheric air, in the liquid form; but with twelve times as much of the active principle, oxygen. It is the most energetic principle in gunpowder. It ignites oil of turpentine, charcoal, and phosphorus.

Nitric acid consists of one volume, or one atom, of

nitrogen, = - - - - - - - -	1.75
with $2\frac{1}{2}$ volumes, or five atoms, of oxygen = -	5.
Hence the equivalent of the acid is - - -	6.75

The strongest acid which Dr. Thomson was enabled to procure, had the specific gravity of 1.534. He infers, that if the acid contained, for every atom, only one atom of water, its gravity would be 1.55. I quote from this celebrated author the following table, showing the specific gravity of aqueous solutions, of this acid, for every definite compound between the strongest acid, and that which contains 15 atoms of water, for one of acid.

Atoms of Acid.	Atoms of Water.	Acid in 100.	Specific Gravity.
1	1	85·714	1·55
1	2	75·000	1·4855
1	3	66·668	1·4546
1	4	60·000	1·4237
1	5	54·545	1·3928
1	6	50·000	1·3692
1	7	46·260	1·3456
1	8	42·857	1·3220
1	9	40·000	1·3032
1	10	37·500	1·2844
1	11	35·294	1.2656
1	12	32·574	1·2495
1	13	31·579	1·2334
1	14	30·000	1·2173
1	15	28·571	1·2012

EXPERIMENTAL ILLUSTRATIONS.

The extrication and distillation of nitric acid, shown, by means of a glass retort and receiver, heated by a lamp—a chafing dish—or small sand-bath. Its action on various substances exemplified.

OF NITROUS AIR, OR NITRIC OXIDE GAS.

MEANS OF OBTAINING NITRIC OXIDE.

It is evolved during the reaction between nitric acid, and copper, silver, and other metals.

PROPERTIES AND COMPOSITION OF NITRIC OXIDE GAS.

It is permanent over water, by which it is slightly absorbed:—is rather heavier than common air. It is not acid. It extinguishes a candle flame, but ignites Homberg's pyrophorus, and supports the combustion of phosphorus, if inflamed before immersion in it. It is fatal to animals—renders the flame of hydrogen green by mixture—does not explode with it, but does explode with ammonia. It unites rapidly with the oxygen of the air, or of oxygen gas, or any gaseous mixture containing it, producing remarkable red acid fumes, which redden litmus paper, if pasted inside of the glass in which the mixture is made. It is absorbed by the sulphate or muriate of the black oxide of iron. The solution absorbs oxygen, and is, therefore, used in eudiometry. It is decomposed by moistened iron filings: by ignited charcoal, arsenic, zinc, or potassium.

One volume, or one atom, of nitrogen, equivalent -	1.75
And one volume, or two atoms, of oxygen, equivalent	2.
Constitute three volumes, or one atom, of nitric oxide, equivalent - - - - - - - -	3.75

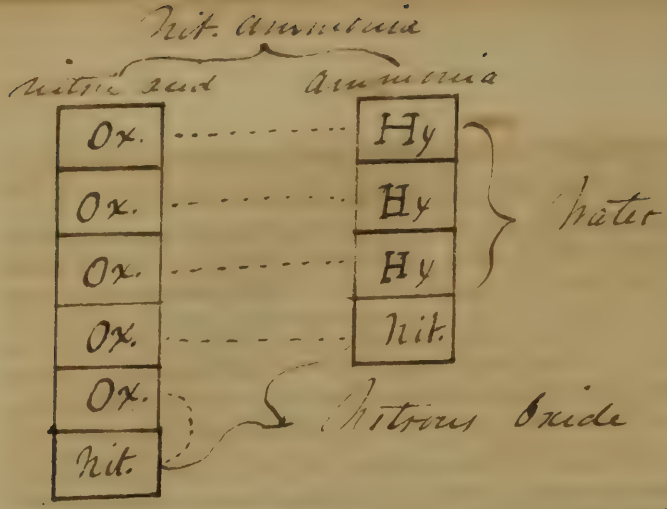
The volumes, of oxygen, and nitrogen, exist, in this gas, without condensation.

EXPERIMENTAL ILLUSTRATIONS OF THE PROPERTIES OF NITRIC OXIDE.

Copper or silver subjected to nitric acid, which ought not to be very weak. The nitric oxide gas, is extricated, and collected in bell glasses, either over water, or mercury.

Absorption of nitric oxide gas, by green muriate, or green sulphate of iron, shown: Also, the method of ascertaining its purity, by the sliding rod eudiometer—and, its application to eudiometry, in various ways, by means of that, and other eudiometrical instruments.

Self-regulating reservoir of nitrous gas, for eudiometrical experiments. Absorption of oxygen gas, by nitric oxide, and the consequent acidity, made evident by the effect on litmus.


Nit. Ammonia
Nitric acid
Ammonia
Ox.
Ox.
Ox.
Ox.
Ox.
Nit.
Hy
Hy
Hy
Nit.
Water
Nitrous Oxide

OF GASEOUS OXIDE OF NITROGEN, OR NITROUS OXIDE.

MEANS OF OBTAINING NITROUS OXIDE.

It may be obtained by the action of dilute nitric acid upon zinc: by exposing nitric oxide gas to iron filings, sulphites, or other substances, attractive of oxygen. It is procured best from nitrate of ammonia, by distillation. The strongest acid may be saturated by the carbonate of ammonia of the shops, in the retort to be used for the distillation, and the distillation proceed forthwith. Nitrous oxide may be advantageously received and kept for use in leather bags, the junctures riveted, filled by an appropriate apparatus. As it is absorbed by water, it cannot be kept over this fluid, without loss.

RATIONALE OF THE FORMATION OF NITROUS OXIDE, BY THE DISTILLATION OF NITRATE OF AMMONIA.

PROPERTIES AND COMPOSITION OF NITROUS OXIDE.

It is a permanent gas. Its weight to common air, is as 16 to 10. It supports the combustion of a candle-flame vividly; though nitric oxide gas, containing twice as much oxygen, does not. Phosphorus is difficult to inflame in it, but burns, with rapidity, when once on fire. The habitudes of sulphur are, in this respect, analogous to those of phosphorus. An iron wire burns in it, as in oxygen gas. Nitrous oxide may be exploded with hydrogen, forming water, and sometimes nitric acid. It combines with alkalies, only when nascent, which nevertheless remain alkaline. It has no attribute of acidity. It stimulates, and then destroys, life. Its effects on the human system are analogous to a transient, peculiar, various, and generally very vivacious inebriety. It is much more rapidly and extensively soluble in water, than oxygen, and does not produce red fumes, or undergo condensation by admixture with nitric oxide. It is supposed to contain twice as much nitrogen, or half as much oxygen, in volume, as nitric oxide does.

Half a volume of oxygen gas, or one atom, equivalent	1.
With one volume, or one atom of nitrogen, condensed into one volume, equivalent - - - - -	1.75
Constitute one atom of nitrous oxide, equivalent - -	2.75

EXPERIMENTAL ILLUSTRATIONS.

The process and apparatus for producing, catching, and breathing, the nitrous oxide gas, exhibited. The effect on a lighted candle, and on an iron wire, shown:—also, the effects of breathing the gas, on the human system.

OF THE NITRATES.

They are characterized by deflagrating with charcoal, and decomposition, per se, by heat, leaving a residuum of their base.

Chlorates also deflagrate with charcoal, but are rarely met with—and leave a chloride, after exposure to a red heat. Nitrate of potash, or nitre, is one of the most important productions of nature, forming five-sevenths of the ingredients in gunpowder. It is obtained by lixiviation, from the soils of certain territories in India and Spain, and other countries; also from the earths of cellars, and large caves.

OF NITROUS ACID.

This is a compound of one atom of nitrogen, with four atoms of oxygen. It is formed by mixing, in an exhausted receiver, one volume of oxygen gas, with two volumes of nitric oxide. As nitric oxide contains a volume of each gas, the acid formed must comprise two volumes oxygen, equivalent to four atoms, and one volume of nitrogen, equivalent to one atom.

This acid is formed when nitrates are moderately heated, in which case, they lose a half volume of the oxygen, of their nitric acid, or just so much, as is requisite to convert the one acid, into the other.

From the nitrite of lead thus prepared, the acid may be liberated, by sulphuric acid, and may be condensed in water, or in a receiver, surrounded by snow and salt.

Nitrous acid is interesting, rather as an object of scientific curiosity, and from its relation to nitric acid, than from any inherent usefulness.

OF THE COMPOUNDS OF CHLORINE.

OF MURIATIC, OR HYDROCHLORIC ACID.

Chlorine and hydrogen gases, when mixed, in equal volumes, slowly combine, and form muriatic acid. If exposed to light, or the electric spark, a detonation ensues. The direct rays of the sun are not necessary, according to Silliman's experiments. When dry, muriatic acid is produced in the form of a gas; but is absorbed, if a small proportion of water be present, and forms liquid muriatic acid.

MEANS OF OBTAINING MURIATIC ACID GAS.

Distil two parts of common salt, with one part of sulphuric acid, in a glass, porcelain, or iron retort.

PROPERTIES AND COMPOSITION OF MURIATIC ACID GAS.

It has all the attributes of a gas.—It is colourless—and although less active than chlorine gas, is, to the organs of respiration, intolerably irritating—and, if not very dilute, deleterious to life. On escaping into the air, it produces white fumes, from its meeting

with aqueous vapour. Its affinity for water, is so great, that this liquid will take up 420 times its bulk—and ice melts in it, as if surrounded by fire. The alkaline metalloids decompose it, by combining with its chlorine, while its hydrogen separates in the gaseous state. It is susceptible both of decomposition, and recomposition, by electricity. Equal weights of potassium separate the same weights, or volumes of hydrogen, from muriatic acid, and from water; a result coincident with the atomic theory.—Muriatic acid gas is resolved, when electrified with oxygen, into water and chlorine. It combines with pure barytes and strontites, producing a chloride, and water. On being mixed with ammoniacal gas, very dense fumes are produced of muriate of ammonia. The fumes arising thus from the mixture of ammonia with muriatic acid gas, renders either susceptible of detection, by means of the other.

One volume, or one atom, of chlorine, equivalent -	4.5
With one volume, or one atom, of hydrogen, equivalent	.125
Constitute two volumes, or one atom, of muriatic acid gas, equivalent - - - - - - -	4.625

OF LIQUID MURIATIC ACID.

MEANS OF OBTAINING LIQUID MURIATIC ACID.

It is obtained, by saturating water with the gas, in a Woulfe's apparatus,—or in mine. The solution is nearly pure, in all the receptacles, excepting the first. The liquid acid is also procured, by distilling a solution of common salt with sulphuric acid, and condensing the product in a receiver.

PROPERTIES OF LIQUID MURIATIC ACID.

When concentrated, it produces suffocating fumes, from an escape of gas. When pure, it is colourless—though usually straw-coloured, from a minute adulteration by iron. Muriatic acid *can be said to combine with those alkalies, earths, and oxides only, which form, with it, soluble salts.* Its combinations are, for the most part, by heat, and desiccation, convertible into chlorides;—muriate of magnesia, and muriate of alumine, are exceptions—also muriate of ammonia, of which there can be no chloride, since chlorine decomposes it, by its affinity for hydrogen.

Dr. Thomson informs us that the strongest acid, which he could obtain, consisted of one atom of acid, equivalent 4625, united with six atoms of water, which being 1125, each makes the aggregate weight of the water 6750. Of course the proportion of the one to the other was as those numbers or nearly, as 100 to 40. I subjoin a table, from this author, showing the number of atoms of acid, and water, in solutions of different gravities.

TABLE EXHIBITING THE SPECIFIC GRAVITY OF MURIATIC ACID OF DETERMINATE STRENGTHS.

Atoms of Acid.	Atoms of Water.	Acid in 100.	Specific Gravity.
1	6	40·659	1·203
1	7	37·000	1·179
1	8	33·945	1·162
1	9	31·346	1·149
1	10	29·134	1·139
1	11	27·206	1·1285
1	12	25·517	1.1197
1	13	24·026	1·1127
1	14	22·700	1·1060
1	15	21·512	1·1008
1	16	20·442	1·0960
1	17	19·474	1·0902
1	18	18·590	1·0860
1	19	17·790	1·0820
1	20	17·051	1·0780

EXPERIMENTAL ILLUSTRATIONS.

Equal volumes of hydrogen and chlorine, being mixed and subjected to the solar rays, or galvanic ignition, explode, and form muriatic acid gas.

Evolution of muriatic acid gas from a retort, containing common salt and sulphuric acid, aided by heat.

Gas collected over mercury in tall jars. Water, coloured by litmus, being introduced, rapidly changes to a red colour, and causes the disappearance of the gas. Ice introduced, melts quickly into water, which absorbs the gas. Ammonia being mixed with it in due proportion, dense fumes of sal ammoniac ensue.

The gas being passed through water in an impregnating apparatus, the aqueous solution is obtained.

ON THE DIFFERENCE BETWEEN A CHLORIDE, IN SOLUTION, AND A MURIATE.

A chloride, when dissolved in water, contains the same elements as a muriate, but in a different order—as may be seen, by writing them down as follows:

$$\underbrace{\underbrace{\text{Hydrogen, chlorine.}}_{\text{Muriatic acid}}\quad\underbrace{\text{Oxygen, metal.}}_{\text{Oxide.}}}_{\text{Muriate.}}$$

Hydrogen, oxygen. — Chlorine, metal.

Water. — Chloride.

Dissolved Chloride.

It is probable that the order last mentioned, prevails in the compounds found by muriatic acid, with barytes, strontites, lime, potash, and soda; because, by ignition, they are deprived of their oxygen and hydrogen, in the form of water; leaving their chlorine and metal united. But the other arrangement exists, probably, with respect to the muriates of magnesia, and alumine; since, on exposure to ignition, hydrogen and chlorine escape from them, as muriatic acid, leaving the oxygen in union with the metal. Besides these equivocal compounds, there are substances, formerly called muriates, now decidedly considered as chlorides. As, for instance, calomel, luna cornea, plumbum corneum, butter of antimony, or of bismuth, fuming liquor of Libavius, and other metallic combinations, either insoluble in water, or incapable of mixing with it, without some striking change.

GENERIC CHARACTER OF MURIATES, OR SOLUBLE CHLORIDES.

They precipitate solutions of silver, lead, or black oxide of mercury. When concentrated, they give off muriatic acid gas, by the affusion of sulphuric acid. They are not generally decomposable by heat. Muriate of magnesia is the only important exception. They do not deflagrate with charcoal—nor do they, like sulphates, after being heated with it, on being moistened, yield the odour of sulphuretted hydrogen.

COMPOUNDS OF CHLORINE WITH OXYGEN.

Chlorine, passed into alkaline solutions, decomposes water—forms muriatic acid with hydrogen—and another acid with oxygen, called chloric acid. The acids thus generated, form, severally, chlorates and muriates.

ON THE CHLORATES.

ON THE PROCESS FOR OBTAINING THEM.

PROPERTIES OF THE CHLORATES.

They deflagrate like the nitrates, but leave a residuum of chloride, after the ignition. They yield pure oxygen at a temperature just below a red heat. When mixed with combustibles, as sulphur or phosphorus, they ignite by triture, or percussion—also, by the affusion of sulphuric acid. With the same acid, they inflame alcohol and oil of turpentine, and phosphorus even under water.

EXPERIMENTAL ILLUSTRATIONS.

Apparatus for procuring chlorates, exhibited.

Chlorate of potash, and sulphur, being separately pulverized, and then mixed, a blow, or friction, causes the mixture to explode.

Phosphorus being minced by a knife, and mingled with chlorate, a portion of the mixture, rubbed by a pestle, explodes.

Another portion, being allowed to sink to the bottom of a glass vessel containing water, sulphuric acid is poured down by means of a tube, when a brilliant ignition ensues.

OF EUCHLORINE, OR OXIDE OF CHLORINE.

OF THE MEANS OF OBTAINING EUCHLORINE, OR OXIDE OF CHLORINE.

It is obtained by heating, gently, a portion of chlorate of potash, under about twice as much muriatic acid, of moderate strength, as will cover it. The retort should only be subjected to the flame of a small spirit lamp. This should be applied immediately under the acid, so as not to heat the body of the vessel,—otherwise an explosion will probably take place.

OF THE PROPERTIES OF EUCHLORINE, OR OXIDE OF CHLORINE.

Euchlorine is gaseous, but absorbable by water, to the extent of eight or ten times its volume. It is a binary compound of one atom of oxygen, and one of chlorine. The warmth of the hand, is sufficient to cause it to detonate, and to separate into its gaseous elements, occupying one-fifth more space. Antimony, or arsenic, in powder, or Dutch leaf, causes it to explode, by an attraction for the chlorine.

EXPERIMENTAL ILLUSTRATIONS.

Euchlorine, generated by the process abovementioned, and collected over mercury. A tube, filled with it, is made to explode by surrounding it by a red-hot iron ring. Enlargement of bulk, after the explosion, shown, and subsequent absorption of the chlorine by the mercury. The residual gas shown to be oxygen. Portions of euchlorine exploded, by Dutch gold, antimony or arsenic.

OF PEROXIDE OF CHLORINE.

ON THE MEANS OF OBTAINING PEROXIDE OF CHLORINE.

It is obtained by mixing chlorate of potash, with sulphuric acid, and distilling with great caution, at a heat below 212°. The process is too dangerous to be repeated without great caution.

OF THE PROPERTIES OF PEROXIDE OF CHLORINE.

They are those of euchlorine, but are more intense. According to Brande, it is only a purer euchlorine.

EXPERIMENTAL ILLUSTRATION.

Mixture of chlorate of potash, and sulphuric acid, introduced into a glass tube suspended, by a wire, within a strong glass cylinder. Heat being applied, the peroxide is evolved, and exploded; while the surrounding cylinder, protects the operator from injury.

OF CHLORIC ACID.

MEANS OF OBTAINING CHLORIC ACID.

It is obtained by passing chlorine through water, containing oxide of silver in suspension.

OF THE PROPERTIES OF CHLORIC ACID.

It is colourless—sour and astringent. When warm and concentrated, its odour is pungent. It reddens litmus. It does not precipitate solutions of lead, mercury, or silver. It is partially decomposed by distillation. With muriatic acid, it produces water, and chlorine.

OF THE COMPOSITION OF CHLORIC ACID.

It is supposed to consist of one atom of chlorine, and five atoms of oxygen.

OF PER-CHLORIC ACID.

OF NITRO-MURIATIC ACID.

It is a mixture of nitric, with muriatic acid.

PROPERTIES OF NITRO-MURIATIC ACID.

The colour of nitro-muriatic acid is much deeper than that of its constituent acids; and its fumes are more pungent, being evidently chlorine, the muriatic acid having been dehydrogenated by the oxygen of the nitric acid. The effects of nitro-muriatic acid differ from those of a solution of chlorine in water, only in being more powerful, as there is a greater quantity of chlorine in the same space.

ACTION OF CHLORINE ON GOLD.

Some gold leaf is placed in two glasses—nitric acid is added to one glass, and muriatic acid to the other glass: The gold is not acted upon. The contents of one glass being added to the other, the gold disappears.

ON THE COMPARATIVE ACTION OF SULPHURIC, NITRIC, MURIATIC, AND NITRO-MURIATIC ACIDS.

Sulphuric acid carbonizes organic products, by its avidity for the elements of water. In this respect, it has more analogy with caus-

tic alkalies than acids. When boiled on metals, they are oxidized at its expense. When cold, and diluted with water, the metals, on which it acts, are oxidized, at the expense of the water.

Whether cold, or hot, nitric acid acts both on metals, and upon organic products, by imparting oxygen. Hence, when cold, its action on metals is analogous to sulphuric acid, when boiling.

The action of muriatic acid on organic products is very slight: —upon metals, with heat, it resembles that of nitric acid, and boiling sulphuric acid; excepting, that it imparts chlorine, instead of oxygen. When it acts on metals, in the cold, it evolves hydrogen; which may come from the decomposition of the acid, though usually supposed to arise from the decomposition of water; since dilute sulphuric, and muriatic acids, may both be considered as containing simple radicals, acidified by the joint agency of hydrogen, and oxygen.

ON THE BLEACHING PROCESS.

ON THE OLD THEORY OF THE NATURE OF CHLORINE.

Muriatic acid was deemed to be a compound of oxygen and some unknown radical—When distilled from oxide of lead, or manganese, it was supposed to combine with a portion of the oxygen of the oxide, forming oxygenated muriatic acid. The oxygen was supposed to be held by a weak affinity, as in nitric acid. To this oxygen, thus contained, its activity, as a supporter of combustion, or a solvent of metals, was ascribed. It has since been proved, that when dry, it does not oxydize. Charcoal is not acted upon, when ignited in dry chlorine by voltaic electricity: nor are metals. They are converted into substances now called chlorides. The chlorides of sulphur and phosphorus, which result from exposing these substances to chlorine, are devoid of acidity, though the addition of water, converts the one into muriatic and sulphuric acids, the other into muriatic and phosphoric acids. If chlorine be an oxygenated acid, the discovery of euchlorine, and chloric acid, must establish the following anomaly—that the radical of muriatic acid, acidified by oxygen, on further additions of the acidifying principle, loses its acidity, and forms two oxides—chlorine and euchlorine; and yet, by a subsequent addition of the same principle, regains the acid state.

Thenard has lately oxygenated muriatic acid; or, more properly, the water in it. The fluid, thus containing muriatic acid and oxygen in excess, has no resemblance to chlorine.

The process, by which iodine is obtained from hydriodic acid, is analogous to that, by which chlorine is obtained from muriatic acid; yet iodine is not considered as an oxygenated acid.

OF PHOSPHORUS.

MEANS OF OBTAINING PHOSPHORUS.

It is obtained from the phosphate of soda in urine, or the phos-

phate of lime in bones. Phosphoric acid is extricated from the earth of bones, by the stronger affinity of sulphuric acid.* Phosphoric acid is decomposed by ignition with charcoal in a retort, from which it distils in tears, which are melted and strained under water. The phosphate of soda is decomposable by nitrate of lead, by complex affinity. The resulting phosphate of lead, is decomposable by distillation, at a high heat, with carbon.

OF THE PROPERTIES OF PHOSPHORUS.

It is often of a light flesh colour—but when pure is colourless and translucent. It is rather harder than wax, but more easily split by the knife, under which, after some pressure, it yields suddenly. It boils at 550° (F.) and in a retort filled with hydrogen may be distilled. By these means, it may be separated from the phosphuret of carbon, which, more or less, according to Thenard, always contaminates it. Hydrogen is evolved by electro-chemical action; but is present in the phosphorus, as an impurity, not as a constituent. Phosphorus is susceptible of a slow, and of a quick combustion, producing phosphorous and phosphoric acids. The existence of other compounds of phosphorus and oxygen has been alleged. Phosphorus forms a compound with sulphur, which is spontaneously inflammable. The equivalent of phosphorus is 1.5.

EXPERIMENTAL ILLUSTRATIONS.

Phosphorus exhibited, and its combustion in oxygen and in chlorine. Phenomena of its reaction with nitric acid:—also, with chlorates. A combination of sulphur, and phosphorus, spontaneously inflames.

OF PHOSPHORIC ACID.

MEANS OF OBTAINING PHOSPHORIC ACID.

It is obtained, not only, as abovementioned, by the combustion of phosphorus, or decomposition of bones, but best by adding phosphorus, gradually, to nitric acid, heated in a retort.

OF THE PROPERTIES OF PHOSPHORIC ACID.

Though composed of volatile ingredients, phosphoric acid is one of the most fixed, and, per se, unalterable acids, by heat. Evaporated to dryness, and fused, it forms a glass. It is soluble in water—is not odorous. It is supposed to consist of two atoms of oxygen, with one atom of phosphorus. Its equivalent is therefore 3.5.

OF PHOSPHOROUS ACID.

MEANS OF OBTAINING PHOSPHOROUS ACID.

It is obtained, by slow combustion; but is then contaminated by phosphoric acid: better, by the distillation of phosphorus with cor-

* The phosphoric acid is said to be in the state of super-phosphate of lime when thus obtained.

rosive sublimate. Chloride of phosphorus results, which, when mixed with water, produces muriatic and phosphorous acids. The muriatic acid, being most volatile, may be separated by heat.

OF THE PROPERTIES OF PHOSPHOROUS ACID.

It is distinguished from phosphoric acid, by its odious smell, and susceptibility of volatilization.

It consists of one atom of oxygen and one of phosphorus. Consequently its equivalent is 2.5.

OF THE PHOSPHATES, AND PHOSPHITES.

They have the same relation to each other, as sulphates and sulphites—and nitrates and nitrites. The earthy and alkaline phosphates are not decomposed by ignition in contact with charcoal. The metallic phosphates yield phosphorus, when so treated. Hence the necessity of transferring the acid, from soda, to lead, in one of the processes for obtaining phosphorus.

EXPERIMENTAL ILLUSTRATIONS.

Precipitation of silver, lead, and lime, &c. from solution, by phosphate of soda.

OF HYPO-PHOSPHOROUS, OR PER-PHOSPHOROUS ACID.

This acid is said to consist of two atoms of phosphorus, and one atom of oxygen.

OF PHOSPHORUS AND CHLORINE.

There are two chlorides of phosphorus—a chloride and a bi-chloride. The latter is solid, and consists of one atom of phosphorus, and two atoms of chlorine;—the other of one atom of phosphorus and one of chlorine. The bi-chloride produces, with water, muriatic and phosphoric acids;—while the chloride, or proto-chloride, produces muriatic, and phosphorous acids, with water. The bi-chloride having a double proportion of chlorine, requires twice as much hydrogen, and of course liberates twice as much oxygen, from the water, to act on the same proportion of phosphorus.

OF THE COMBINATIONS OF PHOSPHORUS, WITH THE ALKALIES, AND EARTHS; CALLED PHOSPHURETS:—ALSO, ON THE ANALOGY BETWEEN PHOSPHURETS, AND SULPHURETS, BOTH AS TO THEIR ORIGIN, AND THEIR EFFECTS UPON WATER.

EXPERIMENTAL ILLUSTRATIONS.

Decomposition of water by the phosphurets of lime, and potash. Spontaneous combustion and detonation of phosphuretted hydrogen, in atmospheric air, and in oxygen gas

OF BORACIC ACID.

There is a salt called borax, found in Thibet and China, which consists of this acid and soda in excess.

OF THE MEANS OF OBTAINING BORACIC ACID.

To a saturated solution of borax, add half the weight of the salt, in sulphuric acid. The boracic acid crystallizes, by precipitation, in shining scaly crystals, contaminated by sulphuric acid, till purified by fusion. Boracic acid is fusible into a glass, decomposable in the voltaic circuit into oxygen, and an olive-brown matter which is considered as the base of the acid, and is called boron. By means of potassium, which combines with the oxygen of the acid, boron may be procured in greater quantity, in the form of a dark olive powder.

OF BORON.

This substance, as above obtained, takes fire in the air at 600° (F.) and burns brilliantly when ignited in oxygen gas. It is acidified, when exposed to nitric, or sulphuric acids.

The equivalent of boron is 1; and as the acid is a ternary compound, of boron and oxygen, its equivalent is 3.

OF BORATES.

Borax, or sub-borate of soda, above spoken of, is the only important combination under this head. Fused into a glass, it is of great use in blow-pipe assays, and in soldering.

OF FLUORIC ACID.

OF THE MEANS OF OBTAINING FLUORIC ACID.

Fluor spar is pulverized, and heated with twice its weight of strong sulphuric acid, in a leaden retort, adapted to a leaden receiver, surrounded by snow and salt. The acid condenses in a liquid state in the receiver.

OF THE PROPERTIES OF FLUORIC ACID.

It is so volatile, that it cannot, in a close apartment, be decanted, without subjecting the operator to intolerable fumes. This operation must be performed where there is a current of air to carry them off. It ulcerates the skin wherever it falls. It corrodes glass so rapidly as to leave an indelible trace in running over its surface. It must be kept in vessels of silver or lead, accurately closed. It may also be received in water, in which it may more easily be condensed and preserved.

EXPERIMENTAL ILLUSTRATIONS.

Powdered fluor heated with sulphuric acid, in a leaden retort, adapted to a receiver surrounded by snow and salt. Same process, substituting a receiver with water, by means

of Knight's apparatus. Effects of fluoric acid upon glass, shown.

OF THE NATURE OF FLUORIC ACID.

It is probably composed of hydrogen, and a principle called fluorine, supposed analogous to chlorine and iodine, and which forms acids with hydrogen, silicon, and boron.

PROOFS OF THE EXISTENCE OF FLUORINE, FOUNDED ON VOLTAIC ANALYSIS.

OF FLUORIDE OF SILICON, OR FLUO-SILICIC ACID GAS, USUALLY CALLED SILICATED FLUORIC ACID.

It is obtained by adding, to the materials for producing pure fluoric acid, one half the weight of the fluor, in powdered glass, in a glass retort, and distilling. The product, being gaseous, is received in bell glasses, over mercury.

PROPERTIES OF SILICATED FLUORIC, OR FLUO-SILICIC ACID.

It is a gas permanent over mercury. On mixing with air, it fumes, in consequence of the moisture; in which respect, as well as in its odour, and other obvious habitudes, it much resembles muriatic acid. When presented to water, a white deposition takes place, while the gas appears to be absorbed. This deposition was heretofore considered as pure silex. According to Brande, the gas, on meeting with water, forms two compounds, of fluoric acid with silex—one insoluble and insipid, the other soluble and acid.

EXPERIMENTAL ILLUSTRATIONS.

Production of the fluo-silicic acid shown. Its absorption by water—precipitation of silex.

OF THE FLUATES—OR, MORE PROPERLY, FLUORIDES.

The fluates are not of much importance in the arts. The alkaline fluates are tests for lime.

The fluates, so called, are properly fluorides; as are the muriates, when yielding chlorides (not oxides) by heat.*

FLUORINE WITH BORON.

FLUO-BORIC ACID GAS, OR FLUORIDE OF BORON.

It is obtained by distilling fluor spar, in powder, with dry boracic acid, (in proportion of one part of the acid to two parts of the fluor or fluoride of calcium,) in an iron tube at a strong heat. Or the same materials may be distilled, by means of a glass retort, with twelve parts of sulphuric acid.

Fluo-boric acid gas is produced, and may be collected, in the gaseous state, over mercury.

See page 62.

PROPERTIES OF FLUORIDE, OF BORON, OR FLUO-BORIC ACID GAS.

It is analogous to fluoride of silicon, but more intensely attracts moisture. Water absorbs 700 times its bulk, becoming nearly as heavy, and corrosive of organic matter, as concentrated sulphuric acid. In this state, it appears to consist of the same elements as fluoric and boracic acids;—but, as it does not corrode glass, there seems to be an intimate union of the fluorine with the boron, as well as with the hydrogen.

EQUIVALENTS OF FLUORINE AND ITS COMPOUNDS.

An atom of fluorine is equivalent to 2.25, and with one atom of hydrogen, forms fluoric acid, equivalent, 2.375. With one atom silicon, forms fluo-silicic acid gas, equivalent 3.25—also, with two atoms of boron, each equivalent 1. forms fluo-boric acid, equivalent 4.25. Fluor spar consists of one atom calcium, equivalent 2.5, and one atom fluorine, and of course is equivalent to 4.75.

OF THE METALS.

Besides the alkaline metalloids already treated of, there are twenty-nine metals. Their names are: gold, platina, silver, mercury, rhodium, palladium, iridium, osmium, copper, iron, nickel, tin, lead, zinc, bismuth, antimony, tellurium, selenium, arsenic, cobalt, manganesium, chrome, molybdenum, uranium, tungsten, titanium, columbium, cerium, cadmium.

GENERIC CHARACTERISTICS OF THE METALS.

Substances belonging to this class, have a specific gravity, not less than six, and, when newly cut, a peculiar lustre. They are the best conductors of heat, and electricity; the worst radiators, and best reflectors, of heat. All combine, directly or indirectly, with oxygen, chlorine, and sulphur, in one or more proportions—forming oxides, chlorides, and sulphurets; and all are susceptible of solidity and fluidity, and probably of the aëriform state. Mercury and arsenic are easily volatilized: and gold, silver, and platina, though very difficult to burn or volatilize, are nevertheless dissipated and oxidized, by means either of the compound blowpipe, galvanism, or electricity.

OF THE PROPERTIES POSSESSED BY SOME METALS, BUT NOT BY OTHERS.

The properties which come under this head, are: permanency of lustre in the fire and air—malleability—ductility—elasticity—sensibility to the magnet—susceptibility of the welding process—and of acquiring, by a union with carbon, silicon, or aluminum, the property of hardening by sudden refrigeration.

The metals remarkable for permanency of lustre, are—gold, pla-

tina, silver, and palladium. Those principally remarkable for malleability, are—gold, silver, platina, copper, palladium, iron, tin, lead. Among these, iron and platina only, can be advantageously hammered at a very high temperature.

The metals distinguished for elasticity, are—[illegible] copper, and silver. It is a quality which appears dependent on the approximation of their particles, and expression of their caloric by the hammer, rollers, or wire drawing. Iron, in the state of steel, when duly tempered, is pre-eminent for this property.

The metals remarkable for ductility, are—gold, iron, (either as iron or steel,) silver, copper, platina, tin, and lead. In large rods or pipes, lead and tin are the most ductile.

The magnetic metals are—iron, whether pure, in the state of steel, or in that of protoxide, and nickel. Those susceptible of the welding process, are, iron and platina. Iron only, is capable of uniting with carbon, silicon, or aluminum, and hardening, consequently, by quick refrigeration. Gold and platina, are distinguished by their superior gravity, which is between two and a half, and three times greater, than that of iron, tin, or zinc. The gravity of mercury is about one-third, that of lead one-half less than gold or platina.

The perfect metals are those which, like gold, silver, platina, and palladium, possess ductility and malleability, and which are not tarnished by exposure to the air, or oxidized by the highest heats of the air furnace, or forge.

OF THE BRITTLE METALS, OR SEMI-METALS.

The latter appellation was given to those metals, which, like bismuth, antimony, cobalt, &c. could not, from their brittleness, be wrought under the hammer. They are now called, by some chemists, brittle metals. Zinc, till lately, was placed among the semi-metals; but, at this time, ought to stand between the two classes, being laminable by rollers, but not malleable.

OF ALLOYS.

This term is given to the compounds formed by the union of diferent metals. There is always copper in gold and silver coin; and in the metal, employed under those names by the smiths and jewellers, there are various proportions of the baser metal. Brass consists of copper and zinc. Pewter, of lead and tin; or tin, copper, and antimony.

OF AMALGAMS.

These are the compounds of mercury with other metals.

OF THE NOMENCLATURE OF METALLIC OXIDES, CHLORIDES AND SULPHURETS.

Metals are susceptible of different degrees of oxidizement. To distinguish these, the terms protoxide, deutoxide, and tritoxide, are used, to designate the first, second, and third degree. That oxide which contains most oxygen, is called the peroxide. In like

manner, chlorine and sulphur combine in different proportions. Hence we have proto-chloride and proto-sulphuret, deuto-chloride and deuto-sulphuret, and per-chloride and per-sulphuret; also, chloride and bi-chloride, sulphuret and bi-sulphuret, or super-sulphuret.

OF GOLD.

MEANS OF OBTAINING GOLD.

Gold is occasionally found in nature, nearly pure. It is not liable, like other metals, to be degraded by a union with oxygen or sulphur. The precipitate obtained from a solution of gold coin, in nitro-muriatic acid, by green sulphate of iron, is pure gold. This metal is also purified by exposure to heat and air, or nitric acid, by which means baser metals are oxidized, as in the processes of cupellation, and parting.

From the sands or ores in which they exist naturally, minute portions of gold are collected, by trituration with mercury, in which they dissolve. They are separated from the mercury, by distillation.

OF QUARTATION AND PARTING—OF CUPELLATION.

PROPERTIES OF GOLD.

Its colour and lustre are well known. Its gravity is 19.3; that is, the weights of equal bulks of gold, and water, are, to each other, as 19.3 to one. It is the most malleable and ductile metal, and suffers the least by exposure to air and moisture. Gold leaf, which is about 1000 times thinner than printing paper, retains its lustre in the air. Gold leaf transmits a greenish light, but it is questionable, if it be truly translucent. Placed on glass, and viewed by transmitted light, it appears like a retina. It is erroneously spoken of, as a continuous superficies.

Gold fuses at a low white heat, but requires the temperature produced by the compound blowpipe, or galvanism, or the explosive power of electricity, to volatilize or oxidize it. Its not being liable to injury from exposure, is due to its weak affinity for oxygen or sulphur. There are two oxides of gold, a protoxide, and a peroxide—It is uncertain whether the latter contain 2, or 3 atoms, of oxygen.

Neither sulphuric, nor nitric acid, has any action on gold. With the oxides, they combine, but the compounds, thus formed, are not crystallizable.

It has been already stated, that chlorine exercises a very energetic affinity with gold. A combination between them ensues, whether the metal be heated in the gas, or presented to it in the aqueous solution, or in nitro-muriatic acid.* The dissolved chloride, or muriate of gold, yields triple salts with the alkalies. The

* See page 65.

compound formed with ammonia, fulminates by percussion, or at a heat of about 400° (F.).

Sulphuretted hydrogen precipitates gold in the state of a sulphuret, which may be dissolved by liquid alkaline sulphurets.

When a solution of muriate of gold is mixed with sulphuric ether, the ether takes the metal from the acid, and dissolves it. If iron or steel be moistened with this ethereal solution, it is productive of a slight gilding.

Phosphorus, carbon, and the baser metals, also hydrogen gas and its compounds, by attraction for oxygen, precipitate gold in the metallic form. Muriate of tin, or tinfoil, furnishes a purple precipitate. Hence tin, especially in the state of muriate of the protoxide, or dissolved proto-chloride, is the best test for gold.

Gold combines with almost all the metals, and amalgamates eagerly with mercury.

The equivalent for gold is 25.

EXPERIMENTAL ILLUSTRATIONS.

Gold dissolved by nitro-muriatic acid, and precipitated by sulphate of iron, or by muriate of tin. A cylinder of phosphorus, immersed in a solution of the metal, acquires the appearance of a cylinder of gold. Separation of gold, from its solution, by ether. Effects of the ethereal solution exhibited. Action of mercury on gold leaf.

OF PLATINA, OR PLATINUM.

MEANS OF OBTAINING PLATINA.

This metal, in the crude state of its native grains, as it comes from South America, may be dissolved in nitro-muriatic acid. A solution of sal ammoniac being added, an orange coloured precipitate results, of ammoniacal muriate of platinum. Ignition develops the metal from this precipitate, but in a divided state. By intense pressure, the minute particles, thus procured, are made to cohere, so far, as to sustain the welding process. By this they are made to coalesce, into a perfectly solid and coherent mass.

PROPERTIES OF PLATINUM.

The colour of this metal is intermediate between that of silver, and steel. Its specific gravity is 21.5. It is the heaviest body in nature, being about twice as heavy as lead, and nearly three times as heavy as iron. A cubic inch weighs nearly a pound. It is less ductile and malleable than gold, but harder and more tenacious—though, in these respects, inferior to iron. Like iron, it is susceptible of being hammered and welded at a white heat. It can neither be oxidized nor melted, by the highest temperatures of the air furnace, or forge. It was first fused in a focus of the solar rays—afterwards by means of a stream of oxygen gas on ignited charcoal—but much more easily by my compound blowpipe, under which, it was first

oxidized and dissipated by heat. It fuses and burns easily in the voltaic circuit, and is dispersed and oxidized by mechanical electricity. It is one of the worst conductors of heat among metals.

In its habitudes with oxygen, chlorine, or the acids, it is very analogous to gold, being, like that metal, detected by muriate, or proto-chloride of tin, which produces a claret colour with platina. It unites so energetically with tin, at a red heat, as to occasion the phenomena of combustion. With mercury it amalgamates by trituration, when in a divided state, as obtained by igniting the ammoniacal muriate.

The equivalent of platinum is 12. It forms two oxides, one containing an atom, the other three atoms, of oxygen.—The latter, only, has been isolated.

EXPERIMENTAL ILLUSTRATIONS.

Platina exhibited, in the state of native grains, and in that of larger masses. Precipitated from its solution, by muriate of ammonia, and muriate of tin. A precipitate produced in salts of potash, by muriate of platina, distinguishes them from salts of soda. Combustion of platina with tinfoil.

OF SILVER.

MEANS OF RENDERING SILVER PURE.

A solution of silver coin, in nitric acid, may be precipitated by mercury, and the precipitate ignited to drive off the mercury, which adheres to the precipitate. The first portions of the precipitate, obtained by means of copper, are sufficiently pure. The chloride obtained from the same solution, by common salt, ignited with pearlash, gives pure silver, and it may also be produced, by simply igniting the white crystals, which result, on evaporating the solution, or which spontaneously form in it, when sufficiently concentrated.

PROPERTIES OF SILVER.

In malleability, silver is inferior to gold only. It is also very ductile, and tenacious. Its specific gravity is 10.5. It is the best conductor of caloric. It fuses at a low white heat: It is as difficult to oxidize in the fire, as gold, but is more liable to tarnish, when indiscriminately exposed in the atmosphere, from its susceptibility to the action of sulphur, and chlorine. Hence it is blackened by eggs, and salt water.

By the compound blowpipe, by electricity, or by galvanism, silver is fused, oxidized, and dissipated, as gold is by the same means. Exposed to nitric acid, it is oxidized by one portion, and dissolved by the other. In fact, this acid is its proper solvent. Sulphuric acid has no reaction with silver when cold. At a boiling heat, the metal is oxidized at the expense of one portion of the

acid; and the oxide, thus formed, is dissolved by another portion, as in the case of nitric acid.

Silver unites with chlorine, when heated in it. The chloride of silver, is one of the most insoluble combinations. Hence silver is not soluble in nitro-muriatic acid; and hence, soluble chlorides yield a precipitate when solutions of this metal are added to them: for, in any mixture, those substances will usually unite, which when united, are most insoluble. Gravity, unbalanced by attraction for the solvent, aids in separating them from substances which are so attracted.*

Nitrate of silver, fused, forms lunar caustic; the fused chloride forms horn silver, or luna cornea.

Silver combines with iodine, and sulphur. It forms several fulminating compounds.

The equivalent of silver is 13.75. It forms a protoxide and protochloride, of which the equivalents are of course 14.75 and 18.25. A suboxide of silver is alleged to exist.

EXPERIMENTAL ILLUSTRATIONS.

Oxidizement and solution of silver in nitric acid. Its precipitation by muriates, phosphates, chromates, arsenites, and arseniates, exhibited: also, by copper and mercury. Detonation of fulminating silver.

OF MERCURY, OR QUICKSILVER.

MEANS OF PROCURING MERCURY.

This metal may be found in nature, nearly pure, but much more abundantly in the state of sulphuret, from which it is obtained in purity, by distillation with substances calculated to detain the sulphur.

OF THE PROPERTIES OF MERCURY.

It is the only metal, which is fluid at the ordinary temperatures of the atmosphere. In colour and brilliancy it resembles, and rivals, silver. Its specific gravity is 13.6. At — 39° (F.) it freezes into a malleable solid, and boils at about 660° of the same scale. It forms two oxides, two chlorides, and two sulphurets. The protoxide, or oxide, containing one proportion of oxygen, is black—the deutoxide, containing two proportions, red. The black oxide may be made by mechanical agitation without heat—the red, by long exposure to heat; the air having free access in both cases. The red oxide, is usually obtained by expelling the acid from the nitrate by heat; when thus produced, it retains some nitrogen. It is decomposed at the temperature, at which mercury boils.

* Chloride of silver is, however, very soluble in ammonia, and the solution sometimes yields a fulminating compound. It is said to be decomposable by a current of hydrogen, in the light, but not in the dark; also, by fusion with zinc, or tin:—with zinc, the reaction is violent, so as to cause the fusion of the silver.

When nitric acid, whether cold or hot, is poured on mercury, one portion of the acid is decomposed, imparting oxygen to the metal. The oxide, thus formed, is dissolved by the remaining portion of the acid. When the metal is in excess, the protoxide is principally formed. When the acid is in excess, the deutoxide predominates. Usually, more or less of each oxide is formed. The crystals of the nitrate of the black oxide, are white; those of the nitrate of the red oxide, yellowish.

No reaction arises from adding cold sulphuric acid to mercury; but, when it is boiled on mercury, the phenomena are similar to those which ensue in the case of nitric acid. One portion of the acid, yields oxygen to the metal, the other, combines with the oxide thus created. Each oxide of mercury, forms three salts with nitric acid, a sub, a super, and neutral nitrate. The neutral nitrates of mercury, subjected to water, yield insoluble sub-nitrates, and soluble super-nitrates. The same is true of the sulphate of the deutoxide, which yields turpeth mineral, or the insoluble sub-sulphate, and the soluble super-sulphate, by the affusion of hot water. The nitrate of the protoxide, gives calomel, or proto-chloride of mercury, when presented to muriate of soda. The nitrate of the deutoxide yields, under like circumstances, deutochloride of mercury, or corrosive sublimate. Thus a single proportion of oxygen in the oxide, disengages a single proportion of chlorine; and in like manner, a double proportion of oxygen disengages a double quantity of chlorine. The complex affinity which causes these changes, operates either in the wet, or dry way; that is, whether the substances are mixed in solution, or sublimed together. The sulphate of the deutoxide of mercury produces these results, when sublimed with certain compounds of chlorine, as common salt for instance. Corrosive sublimate is thus procured, and, by trituration with mercury, a second sublimation, and washing in water acidulated with muriatic acid, may be converted into calomel, or proto-chloride. Or the deuto-sulphate of mercury being converted into proto-sulphate, by trituration with a further portion of the metal, sublimation with common salt, yields calomel directly.

Chlorine does not combine with mercury in the indirect mode, abovementioned, only. A jet of chlorine burns spontaneously in mercurial vapour, forming either, or both of the chlorides. The processes for manufacturing these important compounds of mercury, are very numerous. They have, however, but one object—that of presenting chlorine and mercury to each other in due quantities, and in a divided form. In proportion as the chlorine predominates, corrosive sublimate is formed; and, reversing the proportions, calomel.

Corrosive sublimate, is white, more or less crystalline, and transparent,—soluble in about twenty parts of cold water, but more so in hot water—whence crystals are obtained by cooling. It dissolves in two parts of alcohol, and in three parts of ether, by weight. It is not soluble either in sulphuric, or nitric acid. With

the muriates of ammonia, potash, soda, barytes, and magnesia, it forms very soluble compounds. These solutions, and those by ether and alcohol, undergo no change from light.—The caustic earths, and alkalies, disengage an orange precipitate, which deepens by keeping. Corrosive sublimate has a most nauseous metallic taste, and is a virulent poison.

Calomel is also white and crystalline, but usually much more compact. It is tasteless and insoluble—is blackened by alkalies, and presents a yellowish stroke, when scratched.

Pure ammonia occasions a white precipitate from the solution of the deuto-chloride, called in the pharmacopœias, hydrargyrum, precipitatum album.

According to an analysis of Fourcroy, founded on the idea of chlorine being oxygenated muriatic acid, this precipitate contains 81 parts of oxide of mercury, 16 parts of muriatic acid, and 3 parts of ammonia. Agreeably to the view now taken, it is therefore probable, that the ammonia takes chlorine from the mercury, and hydrogen from the water, to form with them muriate of ammonia, which remains in solution; while the oxygen and mercury, liberated, precipitate as oxide, together with a portion of protochloride of mercury and ammonia. The same precipitate is obtained, because the same precursory circumstances arise, on adding a fixed alkali to the solution of muriate of ammonia, and deutochloride of mercury. The alkali liberates from the muriate, ammonia, which then acts as if added to a simple solution of deutochloride.

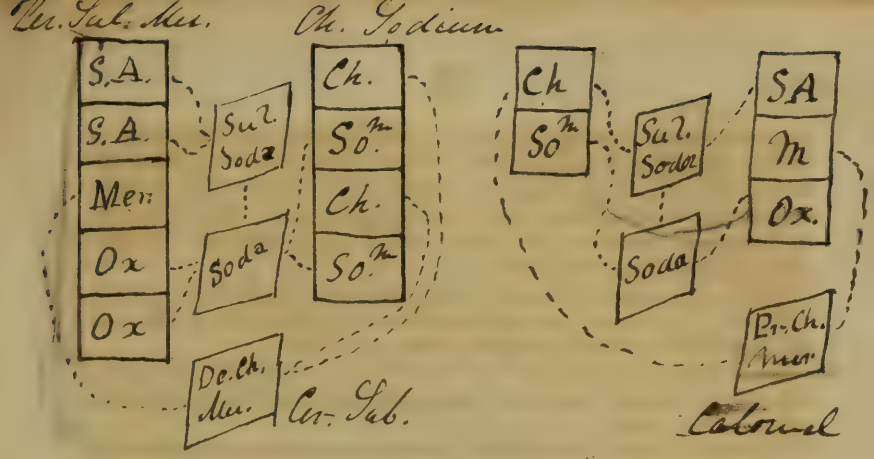
Heated together, mercury and iodine combine, forming either protiodide, or periodide, or both. Iodides are also produced from the nitrates, in the wet way, by the addition of the alkaline iodides, as chlorides are by addition of alkaline chlorides. The protiodide precipitates—the deutiodide, or periodide does not. Mercury combines with cyanogen. The compound is called cyanide, prussiate, or cyanuret of mercury. It is singular that the compound formed by mercury with this factitious principle, should be analogous to those, formed with chlorine and iodine.

Mercury with sulphur forms two compounds, which are black or red, according to the proportions, and the process.

The black compound has been called Ethiops mineral, the red, cinnabar.

Ethiops mineral is made by heating and triturating one part of mercury with three of sulphur; cinnabar, by the fusion and sublimation of five parts of mercury, with one of sulphur. Cinnabar has also been formed by triturating the black sulphuret, with a solution of the caustic potash. Sulphuretted hydrogen deoxidizes the mercury, in mercurial salts, and precipitates it as a sulphuret. It is precipitated from its solution, in nitric acid, by borates, arsenites, arseniates, chromates, and phosphates.

All metals combine with mercury, directly or indirectly. The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Calomel

call-

compounds have the generic name of amalgam. In the case of gold, silver, zinc, lead, tin, and bismuth, the amalgamation is rapidly effected. It is less easily produced with copper, unless when this metal separates mercury from the acids. It is difficult to unite mercury with platina, and still more so with iron; owing, probably, to the great difference in fusibility.

Mercurial compounds are all volatilizable by heat, and mercurial salts, when moistened and rubbed on copper, cover it with a film of mercury.

The equivalents of mercury, and its compounds, with oxygen, chlorine, and sulphur, are as follows:

Mercury,	- - - - - -			equivalent to	25.
Protoxide, 1	atom mercury	with 1	atom oxygen	- -	26.
Peroxide, 1	,,	,, 2	atoms ,,	- -	27.
Protochloride, 1	,,	,, 1	atom chlorine	- -	29.5
Perchloride, 1	,,	,, 2	atoms ,,	- -	34.
Proto-sulphuret 1	,,	,, 1	atom sulphur	- -	27.
Persulphuret 1	,,	,, 2	atoms ,,	- -	29.

OF FULMINATING MERCURY.

EXPERIMENTAL ILLUSTRATIONS.

Ebullition and distillation of mercury. Its compounds with oxygen and sulphur exhibited. Action of nitric acid, and of sulphuric acid, on the metal. Resulting salts subjected to hot water. Black oxide, and red oxide, severally dissolved in nitric acid. Muriatic acid precipitates calomel from the one, but occasions no precipitate in the other. Alkalies produce a black precipitate in the nitrate of the black oxide, or protoxide; an orange precipitate in the nitrate of the red oxide or deutoxide. Similar results obtained, by adding them to calomel and corrosive sublimate; the first giving the black, the last the red oxide. Inflammation of chlorine with mercurial vapour. Explosion of fulminating mercury.

OF COPPER.

Copper is found nearly pure in nature. The copper of commerce contains, according to Berzelius, about one-half of a grain of sulphur and carbon, in one hundred grains.

MEANS OF OBTAINING PURE COPPER

Copper may be purified by solution in concentrated boiling muriatic acid, and subsequent precipitation by a bright plate of iron.

The colours, and lustre of this metal, are well known. Its specific gravity is nearly 9. It is very malleable, very ductile, and tenacious. It fuses at a bright white heat. By exposure to air, it

sustains a slight oxidizement, which is not accelerated nor increased by moisture. At a red heat it oxidizes rapidly, being converted into red oxide, which scales off, if it be afterwards hammered. By further calcination, it is reduced to the state of black oxide. The precipitate from nitrate of copper, by potash, being exposed to a red heat, forms the oxide.

Copper, in thin leaves, takes fire in chlorine, and forms two chlorides—a fixed proto-chloride, and a volatile per-chloride. The per-chloride, when dry, is of a faint yellow colour, but if moistened becomes green—hence it acts as a sympathetic ink, rendered visible by the breath.

Hydriodic acid precipitates copper from its solutions, in the state of an insoluble iodide.

Nitric acid, diluted with three parts water, peroxidizes and dissolves copper. The solution is of a bright blue. It forms elegant blue deliquescent crystals, which moistened and rolled up in tinfoil, ignite it. Heated, they pass to the state of sub-nitrate, of the deutoxide. Sulphuric acid, boiled on copper, per-oxidizes and dissolves it, as nitric acid does without heat. The sulphate resulting, forms beautiful blue crystals, called in commerce blue vitriol. This salt is obtained also by the torrefaction of the sulphuret of copper, and subsequent exposure to moisture and air.

Carbonate of copper is produced, when copper is precipitated from its solutions by alkaline carbonates. It forms on copper, when exposed to most air. It is found native, in various forms, remarkable for beauty.

Alkalies combine with the per-oxide of copper, and with the salts of this metal. Ammonia especially dissolves its oxides; and when they are united to acids, produces triple salts by its union with the compounds. Cuprum ammoniatum is made, by triturating sulphate of copper, with sub-carbonate of ammonia.

Alloyed with a small quantity of tin, copper forms bronze—with a larger quantity, bell metal. Fuzed with zinc, or subjected to the vapour of an ore of this metal, it is converted into brass.

The equivalent for copper is usually assumed as 4, but may be 8.—The equivalents of its compounds may be found, by adding the equivalents of oxygen, sulphur, or chlorine, to one of these numbers.*

* Whether the equivalent of copper be 4, or 8, in the red oxide, the oxygen is, to the copper, as 1 to 8, and the black oxide, as 1 to 4. The equivalent of this oxide must be 10, in one case—in the other, 5. The same observation applies to the chlorides, adding 4.5 for chlorine, to 8 for the first chloride—and adding 4.5 to 4, or 9 to 8, for the second chloride. If the number for copper be 8, the red oxide is a protoxide, and the black oxide, a deutoxide, or peroxide; the first chloride is a proto-chloride, the second a deuto-chloride, or per-chloride. If the number for the metal be assumed as 4, which seems to be preferred, the red oxide is a sub-oxide, the black oxide a protoxide; and the chlorides are a sub-chloride, and a proto-chloride. The case of the sulphurets, will be analogous, excepting that, as there are three sulphurets, one will be a bi-sulphuret, in case copper is 4; and a tri-sulphuret, in case it is 8.

OF VERDIGRIS, OR SUBACETATE OF COPPER.—OF CRYSTALS OF VENUS, DISTILLED VERDIGRIS, OR ACETATE OF COPPER.

EXPERIMENTAL ILLUSTRATIONS.

Solution of copper, and its precipitation by iron. Effect of ammonia: also of ferro-prussiate of potash.

OF IRON.

The mechanical qualities of this metal, are too well known to need description. It is one of the most generally distributed principles in the creation, and probably the most universal colouring matter. It combines greedily with oxygen, forming a black oxide, and a red oxide, and probably others which are of minor importance. Ores of iron are principally of the black, or the red oxide. The black oxide is magnetic; the other may be rendered magnetic, by exposure on charcoal to the blowpipe. The rust of iron is red oxide, combined with more or less carbonic acid. The finery cinder, which flies off from incandescent iron in forging, is the black oxide. This oxide is formed rapidly, when iron wire is ignited in oxygen gas; also, when steam is passed over the metal while white hot. The quantity of oxygen in red oxide, to the quantity in black, is as three to two. Water combines chemically with these oxides, forming hydrates. Ochre is a hydrate, mixed with earthy matter.

Iron is oxidized and dissolved, when subjected either to diluted muriatic, or sulphuric acid. The metal is at first in the state of black oxide, but passes to that of red oxide, by absorbing the oxygen of the air. The green muriate, evaporated to dryness, forms a proto-chloride. The per-chloride is formed by the combustion of iron in chlorine gas.

Nitric acid oxidizes iron, and dissolves the oxide, as in the case of other metals.

Acetic acid causes iron to absorb oxygen slowly, and dissolves the oxide as produced.

The red oxide of iron combines with carbonic acid, and is soluble in water impregnated with this gas.*

There are two native sulphurets of iron, a proto-sulphuret and a deuto-sulphuret: the former only is magnetic, but the latter may be rendered magnetic by roasting, or exposure before the blowpipe, by which it loses one proportion of sulphur, and passes to the state

* The black oxide, in its nascent state, seems to me to be soluble in water: for when copper, or silver, disks, are alternated with this metal, in pure water, a chalybeate taste is acquired; and a precipitate, of red oxide, soon appears. The solution of the black oxide and precipitation of the red oxide, may be observed also at the Yellow Springs, and other chalybeate waters where iron is in solution without any adequate assistance from carbonic acid.

of proto-sulphuret. It is the proto-sulphuret which is formed by the combustion of iron with sulphur. Iron filings and flowers of sulphur, moistened with water, after some time take fire: heated, they incorporate, with the appearance of combustion.

Iron at a welding heat, if touched with a roll of brimstone, falls instantly in drops of melted proto-sulphuret; and an iron wire burns brilliantly, when exposed to a jet of sulphur in vapour, as it issues from the touch-hole of a red-hot gun-barrel, as I have recently ascertained.

Iron combines with phosphorus. The presence of this substance in a small proportion, renders it brittle, while red-hot.

With carbon, iron combines in various proportions, forming steel, cast iron, and plumbago. Plumbago consists of carbon, combined with about six per cent. of iron. It is very difficult of fusion and combustion. It was first fused by me in 1802. The finest kind is seen in the best English pencils. Plumbago of an inferior kind, is used as a material for crucibles and small furnaces.

Cast iron contains not only carbon, but silicon, sulphur, and phosphorus, and probably sometimes calcium. It is purified by long continued fusion, frequent stirring, and subsequent hammering.

Pure malleable iron, thus obtained, is converted into steel, by being heated in contact with charcoal in ovens without access of air. The process is called cementation. The bars are blistered by the operation, as they are seen in commerce. Broken up and welded again, they form shear steel. Fused, they form cast steel. It has lately been advanced, that silicon is a more necessary ingredient in steel, than carbon—and that wootz, or Indian steel, owes its excellence to aluminum as well as silicon.

The hardening and tempering of steel and cast iron, seems to depend on crystallization. The specific gravity is lessened by the hardening.

Iron is equivalent to 3.5, and its protoxide, consequently, is equal to 4.5. The oxygen in the peroxide is the same as if two atoms of iron = 7 were united with three atoms of oxygen: of course its number would be ten, but it is usually represented as consisting of one atom of iron, and $1\frac{1}{2}$ atoms of oxygen, or $3.5+1.5=5$. Either will answer for practical purposes, but the latter is inconsistent with the atomic theory, agreeably to which there can be no half atoms.

ON PERKINS'S PROCESS FOR DECARBONIZING STEEL, AND RECARBONIZING THE IRON OBTAINED.

ON HARDENING AND ANNEALING MALLEABLE METALS IN GENERAL.

ALLOYS OF STEEL WITH RHODIUM, PLATINUM, AND SILVER.

ON TINNING, AND TIN PLATE.

Muriate of Tin is the best remedy for iron mould — the stained part should be moistened, and then you may drop the sol. T. rubbing it in & wash it, removing it if necessary — carefully washed with soap & lye.

The mother water left after saturating potash with chlorine wire effectually takes out fruit & vegetable stains.

OF THE TESTS FOR IRON.

Iron, in the state of red oxide, is precipitated blue by ferro-prussiate of potash—purple or ink-coloured, by infusion of galls or other astringent vegetables—and brown, by succinates, or salts formed by the acid of amber.

There are four principal classes of ferruginous minerals:—magnetic black oxides, and red oxides not magnetic:*—magnetic proto-sulphurets, and deuto-sulphurets not magnetic.—Hence the ores of iron, if not obedient to the magnet, generally become so, after exposure on carbon to the blowpipe, by which the excess of oxygen, or sulphur, which destroys the magnetic power, is expelled.

EXPERIMENTAL ILLUSTRATIONS.

Iron dissolved by muriatic and sulphuric acids. Red and black oxides of iron, and their solutions, exhibited: precipitated by galls, and by ferro-prussiate of potash. Effects of muriate of tin on the colour of the precipitates. Iron burned in oxygen gas—also, by sulphur, and by galvanism. Ores rendered magnetic by the blowpipe.

OF NICKEL.

The colour of nickel is white. It is magnetic—difficult of fusion—malleable—and not easily oxidized by the air. If it could be procured in sufficient quantities, it would be very valuable in the arts. It combines with oxygen, chlorine, iodine, sulphur, and metals. Its oxides are soluble in the acids. Its habitudes with them, are much like those of copper. The solubility of its protoxide in caustic ammonia, is an important mean of separating it from its alloys.

OF TIN.

It is sold in commerce under the name of block tin, to distinguish it from tinned iron plates. In utensils newly made of these, its colour and lustre are seen. It tarnishes slightly by exposure. It is very malleable and ductile. Its specific gravity is 7.9. Excepting bismuth, selenium, and mercury, it is the most fusible metal. It melts at 442° (F.) Tinfoil is $\frac{1}{1000}$ of an inch thick.

Tin is distinguished by producing a peculiar crackling noise, when its ingots are bended, to and fro. It forms two oxides, and two chlorides. The deuto-chloride is a very singular fuming liquid. A small quantity of water congeals it; but a larger, restores its fluidity. This chloride has long been known by the name of the fuming liquor of Libavius.—The protoxide of tin is soluble in diluted nitric acid. In strong acid, it becomes peroxidized, and, in that state, is not soluble. Boiling sulphuric acid, whether strong or weak, converts it into a protoxide, and dissolves it. Solutions

* Considering the number of the oxides of iron doubtful, I designate them by their colour.

of the nitrate, or sulphate, absorb oxygen, and deposite the peroxide, in a state of sub-sulphate, or sub-nitrate. Muriatic acid is its proper solvent; and the compound produced, is usually considered as the muriate of the protoxide. This solution absorbs oxygen, and deoxidizes oxides, in other solutions. Hence it precipitates gold, and platina, and hence it destroys the colour of ink, and Prussian blue. It is always acid.*

Nitro-muriatic acid dissolves tin with violence, producing much heat, and forming a per-chloride in solution. Tartaric acid dissolves tin. Either brass or copper are tinned slightly when boiled with powdered, or leaf tin, and cream of tartar. When cleaned and immersed in melted tin, with addition of oil of rosin, to prevent oxidizement, they become covered with a coat of the fused metal.

Tin forms two sulphurets. The per-sulphuret is of a golden colour, and was known formerly as aurum musivum.

The equivalent for tin is - - - - - - -	7.25
That of its protoxide - - - - - - - -	8.25
of its peroxide - - - - - - - -	9.25
of its proto-chloride - - - - - - -	11.75
The perchloride is probably - - - - - -	16.25

Although the fuming liquor of Libavius appears to contain an excess of chlorine.

EXPERIMENTAL ILLUSTRATIONS.

Tin exhibited, in the state of ingots, and of tinfoil: its deuto-chloride, or the fuming liquor of Libavius, shown. Reaction of nitric acid, or nitrate of copper, with tin powder. Solution of tin, by muriatic acid—and effect of the muriate, thus obtained, on other metallic solutions. Discolouration of ink, and of Prussian blue.

OF BRONZE—OF BELL-METAL—OF SPECULUM-METAL—OF PEWTER.

OF LEAD.

The colour, lustre, and malleability of this metal, are well known. It fuses at about 600° (F.). Its specific gravity is 11.352. It is the most ductile metal in large masses, as it may be drawn into pipes of four inches bore—but it is too deficient in tenacity, to be drawn into fine wire. It is very useful to chemists, being employed in the manufacture of sulphuric acid and chlorine. Leaden tubes and vessels are not easily injured by moisture, or acid fumes.

Two oxides of lead are usually met with in commerce. One

* This does not arise from an excess of acid, as there is none in it which is not essential to the compound. Hydrogen, oxygen, and chlorine, are present—and though tin be combined with them, it does not totally destroy those attributes of acidity, which they otherwise display when united.

called massicot, or when vitrified, litharge; the other minium, or red lead.

A peroxide of lead, of a puce colour, is obtained by exposing red lead, suspended in water, in an impregnating apparatus, to chlorine gas.

Lead is oxidized and dissolved, when subjected to nitric acid. Neither sulphuric, nor muriatic acid, has any action on it, when cold. Sulphuric acid, when boiling and concentrated, oxidizes, and combines with it, forming an insoluble sulphate.

Lead is also oxidized and dissolved by acetic acid, and forms a soluble acetate, and sub-acetate. The acetate is called in commerce, Sugar of Lead.

When exposed to the fumes of vinegar, which consist of acetic acid, and carbonic acid gas, lead is oxidized by the acetic acid, and combines with the carbonic acid, forming ceruse, or the white lead of commerce.

Chlorine combines with lead, but the resulting chloride being fixed and insoluble, protects the metal from further erosion. Hence the utility of leaden vessels, in manufacturing chlorine in the large way.

The most prolific ore of this metal, is the sulphuret, called galena. Exposed to the blowpipe, the sulphur of galena is driven off, and the metal appears in a globule.

Lead is precipitated from its solutions by sulphates, chromates, phosphates, and muriates; and its presence in very small quantity, is shown by sulphuretted hydrogen.

Lead is equivalent to - - - - - - - -	13
Its protoxide to - - - - - - - - -	14
And its peroxide to - - - - - - - -	15

An oxide, which Dr. Thomson calls the deutoxide, is alleged by him to consist of 2 atoms of metal, united with three atoms of oxygen; and of which the equivalent is 29: or, considering it as a compound of 13 lead, and $1\frac{1}{2}$ atoms of oxygen, its equivalent is 14.5.

EXPERIMENTAL ILLUSTRATIONS.

Solution of lead in nitric acid. Its solutions precipitated by sulphates, muriates, phosphates, and chromates. Also by sulphuretted hydrogen. Precipitation of carbonate of lead, from the sub-acetate, by the carbonic acid of the breath. Galena decomposed by the blowpipe flame.

OF ZINC.

This metal is best known in commerce, under the name of Speltre, or Spelter. It is usually adulterated by lead and sulphur; and sometimes by a metal lately discovered, called Cadmium. It may be obtained, pure, by allowing diluted sulphuric acid to act on an excess of the metal, when the zinc will be taken up in preference.

The oxide is to be precipitated from this solution by pearlash, and the metal revived by ignition with charcoal.

PROPERTIES OF ZINC.

Its colour is brilliant white, slightly tinctured with a leaden hue. Its specific gravity about 6.86, being, excepting the metalloids, among the lightest of the metals. Under ordinary circumstances, it is not malleable, but may be laminated by rollers, at a heat somewhat above boiling water. It melts at about 680° (F.). Its structure is strikingly crystalline. It is slightly oxidized by exposure to the atmosphere; but at a white heat, burns rapidly, giving off fumes of oxide. This is the only known oxide of zinc, and consists of about 80 parts metal, and 20 oxygen.

Water is rapidly decomposed, when passed in the state of steam over ignited zinc, or when presented to it together with a due proportion of sulphuric, or muriatic acid.

Zinc is soluble in nitric and muriatic acids, being oxidized by the water in the one case—in the other, at the expense of a portion of the nitric acid. It forms a chloride, when subjected in a divided state to chlorine gas. This chloride has been called, from its consistency, butter of zinc.

Acetic acid may be combined with zinc, by mixing its sulphate, with acetate of lead.

Brass is an alloy of zinc with copper.

The equivalent for zinc is 4.25. It forms but one oxide, whose equivalent is 5.25; as it contains only one atom of oxygen.

EXPERIMENTAL ILLUSTRATIONS.

Zinc subjected to diluted sulphuric, and diluted muriatic acids, severally. Arbor Saturni, produced by it, in a solution of acetate of lead. Combustion of the metal in an incandescent crucible. Its habitudes with the blowpipe.

OF BISMUTH.

This metal is found in commerce in a state of sufficient purity. Its fracture is crystalline, like that of zinc and antimony; but a peculiar blush distinguishes it. Its specific gravity is 9.822. It is not malleable. Excepting selenium, mercury, tin, and the metalloids, it is the most fusible metal. Its fusing point is 476° (F.). It is oxidized, when kept in fusion in the air.

Subjected to sulphuric acid, bismuth is partly dissolved, and partly converted into an insoluble oxide.

Nitric acid dissolves bismuth, and forms a compound, which, when added to water, yields an insoluble hydrated oxide, called magistery of bismuth, or pearl white.

Bismuth, when subjected, in a divided state, to chlorine gas, takes fire, and forms a chloride.

Most of the metals may be alloyed with bismuth. Eight parts

of this metal, with five of lead, and three of tin, form a compound, fusible in boiling water.

Bismuth is used in solder, to render it more fusible.

EXPERIMENTAL ILLUSTRATIONS.

Bismuth, and its oxide, exhibited. Its hue, and habitudes with the blowpipe, compared with those of zinc, antimony, and arsenic.

ON ANTIMONY.

This metal, in the state of regulus, has become an object of commerce, on account of its utility as an ingredient in type-metal, and in pewter.

PROPERTIES OF ANTIMONY.

It is crystalline in its fracture, and of a very fine silver white. It does not tarnish much in the air. It is neither malleable, nor ductile. Before the blowpipe, it fuses at a low red heat, and oxidizes rapidly, and if thrown upon a board, while melted, is dispersed in red-hot globules, whose temperature appears to be sustained by their combustion.

The information given by different chemists, on the subject of antimony, is very discordant. According to Berzelius, there are four oxides. According to Proust, and Brande, there are only two. Henry considers the argentine flowers, which volatilize during combustion, as the peroxide, while Brande alleges that they are the protoxide. Dr. Ure informs us, that antimony forms four oxides, probably—certainly three; and that the deutoxide of Berzelius, is the efficient oxide, which enters into the most useful preparations.

There seems a coincidence between these chemists, so far as this, that the medicinally efficacious antimonial oxide, is that which may be precipitated from a solution of antimony in muriatic acid, by an alkali, or which is obtained by boiling sulphuric acid on the metal to dryness. The oxide thus obtained, by sulphuric or muriatic acid, appears to be the same as that which exists in tartrate of potash and antimony, (tartar emetic,) however this triple compound may be made.

Hence the protoxide of Brande, or deutoxide of Ure, the oxidum antimonii of the pharmacopœias, may be obtained by adding to a solution of tartrate of potash and antimony, sub-carbonate of ammonia, and boiling the mixture till the oxide precipitates.

The peroxide of antimony, is formed by igniting powdered antimony, with six times its weight of nitre. The compound is attractive of alkalies rather than of acids; and therefore may be considered as belonging to the latter class. It is alleged to be inert, medicinally.

There is an oxide of antimony produced, by dissolving the metal in nitric acid, evaporating to dryness, and igniting the residuum.

This, by Berzelius, Ure, Henry, and others, is considered as an intermediate oxide, between that obtained by muriatic or sulphuric acid, or from emetic tartar, and the peroxide (or acid) procured by the action of nitre. It is alleged to have acid properties, and to be the same compound, as the precipitate produced in a nitro-muriatic solution of antimony, by the addition of water. This precipitate has been called powder of Algaroth. It is obtained, when chloride of antimony is thrown into water. The formation of this chloride was shown, in order to illustrate the properties of chlorine as an agent in combustion. Pulverized antimony was spontaneously ignited, in falling through the gas, and chlorides, or butter of antimony, formed. The same compound results from the distillation of corrosive sublimate, with antimony in powder.

Sulphur and antimony exercise a powerful affinity for each other. This metal exists most abundantly in nature, in the state of sulphuret. It is thus found in commerce, under the name of crude antimony; while the metal, as used by type-founders is called regulus of antimony. To obtain antimony from its sulphuret, we are directed to ignite two parts of it, with one of iron filings, and half a part of nitre. The sulphur having a greater affinity for iron, leaves the antimony for this metal, and the nitre probably oxidizes any excess of the sulphur. In order to complete the purification, the impure antimony, thus obtained, must be dissolved in nitro-muriatic acid, and the compound produced subjected to water: the oxide resulting, is then revived by ignition with crude super-tartrate of potash.

When the sulphuret of antimony is roasted, under such circumstances, as to expel a portion of the sulphur, and partially to oxidize the metal; the residuum may be fused into a glass, containing, according to Henry, "eight parts of oxide and one of sulphuret, with ten per cent. of silex." If the quantity of sulphuret be doubled, a compound, called crocus metallorum, is obtained. The metal, in these compounds, is not peroxidized, and is probably in the same efficient state as in tartar emetic. When the sulphuret of antimony is boiled with potash, sulphuretted hydrogen is produced, by the decomposition of the solvent. This combines with the oxide, and forms a hydro-sulphuret of antimony, which precipitates. This hydro-sulphuret has long been known under the name of kermes mineral. After a solution, from which kermes has been precipitated, is cooled, an acid causes a further precipitation of oxide of antimony, combined with bi-sulphuretted hydrogen. The compound thus procured, may be deemed a sulphuretted hydro-sulphuret, and has been known under the name of golden sulphur of antimony.

Sulphuret of antimony, and boiled hartshorn shavings, roasted first, and afterwards ignited in a covered crucible to prevent the too great oxidizement of the metal, constitute the materials of James's powders, or the oxide of antimony with phosphate of lime, or pulvis antimonialis of the pharmacopœias.

According to Brande, the preparations sold under this name,

vary, both with respect to the proportion of the ingredients, and the degree of oxidizement of the metal. According to Philips, they are often inert from containing peroxide only.* A solution of known quantities of phosphate of lime (or bone-earth) and of antimony, in muriatic acid, and precipitation by ammonia, has been proposed as a process, for making a preparation, of a more certain efficacy. It is however suggested, both by Brande and by Philips, that the tartrate of potash and antimony may be advantageously substituted for every other antimonial medicine.

Dr. Thomson, in his late work upon the principles of chemistry, alleges that there are three oxides of antimony: a protoxide, which consists of one atom of metal with one atom of oxygen; a deutoxide, consisting of two atoms of metal, with three of oxygen; and a peroxide, consisting of two atoms of oxygen, with one of metal.

According to the same author, the equivalent of antimony is	5.5
Of its protoxide - - - - - - - - -	6.5
Of its peroxide - - - - - - - - -	7.5

Whilst the equivalent of its deutoxide may be assumed as equal to 7, or to 14, accordingly as it is estimated to consist of two atoms of metal, with three of oxygen, or one atom of metal, with one and a half atoms of oxygen.

According to the same author, there are two chlorides of antimony:

A subchloride, consisting of 2 atoms metal - -	11.
of 1 ,, chlorine - -	4.5
	15.5

Also, a protochloride, consisting of 1 atom metal -	5.5
of 1 ,, chlorine	4.5
	10.

Kermes mineral, agreeably to the same authority, contains of antimony, sulphur, oxygen, and hydrogen, each one atom: that is, of

Antimony	5.5
Sulphur	2.
Oxygen	1.
Hydrogen	.125
	8.625

It may be considered a compound of one atom of sulphuret of antimony, and one atom of water; and may be viewed either as a hydrated sulphuret, or hydro-sulphuretted oxide. In the golden sulphur of antimony, there is probably one atom of sulphur more than in the kermes.

* See Annals of Philosophy, for October, 1822.

EXPERIMENTAL ILLUSTRATIONS.

Antimony and its sulphuret exhibited and exposed to the blowpipe; also the crystals and solution of tartar emetic. Kermes mineral, and golden sulphur of antimony, exhibited. Antimony subjected to acids.

OF ARSENIC.

This metal is sold in commerce under the name of cobalt, and is vulgarly known as fly-stone. In this state, as it is very full of crevices, and exceedingly attractive of oxygen, it is difficult, even by a fresh fracture, to see the true colour or lustre of the metal.

In order to obtain this object in perfection, the cobalt, (as it is absurdly named,) should be pulverized coarsely, and as much introduced into a glass tube, sealed at one end, as may not more than half fill it. The tube should be introduced into a cylinder of iron closed below. The but of a gun-barrel will answer. The space between the iron and the glass should be filled with sand, and another gun-barrel applied above, so as to catch the fumes, and conduct them into a chimney. That portion of the glass tube, which contains the arsenic, should be kept red-hot for about half an hour. After the apparatus is quite cool, the metal will be found in crystals of great splendour, occupying that portion of the glass tube, which was just beyond the red heat.

Arsenic is distinguished from other metals, by its yielding white fumes, which have the odour of garlic, when exposed to the blowpipe, or placed on a hot iron. These fumes, however, might be confounded with those of antimony, by a person deficient of experience, were it not that the latter fuses, before it fumes, and, thrown upon a board, after fusion, spreads itself abroad, in red-hot balls.

According to the opinion of Berzelius, which is adopted by Thenard, the black matter into which arsenic is converted, by exposure to the air, is a protoxide, and the fumes yielded by the combustion of the metal are the deutoxide. These fumes, condensed as they are evolved, on a large scale, during some metallurgic operations, constitute the white arsenic of the shops. By Henry, and many other chemists, white arsenic is considered as the protoxide —and they deem the black matter, into which arsenic is converted by the action of the air, as a mixture of white arsenic with metallic arsenic. This conclusion appears irreconcileable with the fact ascertained by Berzelius, that the exposure of arsenic to air, never causes an absorption of more than eight per cent. of oxygen, while the white oxide contains thirty-two per cent. It seems very improbable, that, under the same circumstances, one portion of the metal should absorb thirty-two per cent. of oxygen, while, by another portion, none is absorbed.

There is also another combination of arsenic with oxygen, obtained by deflagrating the metal with nitre, or by digesting it with nitric acid. In this the oxidizement is admitted to be at a maximum. The white oxide of arsenic, and the peroxide, are also called arsenious and arsenic acids, as they combine with alkalies, and do not combine with acids.

In cases of poisoning by arsenic, we should take the stomach, and dilute the contents — if a white powder may settle at the bottom — this with charcoal+ is to be put in the tube as related — The pure metal is to be distinguished by its fuming very readily, and these fumes will smell like garlic, by its ready oxydation &c —

The ammoniacal acetate nitrate of silver produces a copious yellow precipitate

The ammoniacal nitrate of copper produces Scheele's green, but as the agent has a colour itself, only if the arsenic is in large quantity —

+ It should be the black fine charcoal 1 part — dry carb. pot. 11 parts — this lasts fixes the arsenious acid, & prevents too rapid a volatilization

Sulphuretted Hydrogen produces a yellowish precipitate in arsenious solution - If no precipitate is formed, we may include that there is no metal, tho' if it does occur it may arise from many other metals

Drop the suspected fluid on paper - tho' it draws slowly a stick of lunar caustic - when a stick of India Yellow is formed, & is rough curdy & flocculent if from arsenic - but if from an alkaline phosphate it is smooth and uniform, and in two minutes fades into a sad pearl & finally black

Fowler's solution, is made by boiling pearlash on the white oxide. It is an arsenite of potash. An arseniate is obtained, by deflagrating white oxide with nitre, agreeably to one of the processes of the Pharmacopœias.

Arsenic is found, in nature, in combination with sulphur, in different proportions. The compound containing the least sulphur, is of a fine red colour, and is called realgar—the other sulphuret is yellow, and is called orpiment.

The arsenites, or arseniates, yield precipitates with solutions of copper or silver, and destroy the blue colour of the ioduret of starch. In the instances of copper and silver, arsenites or arseniates of those metals are formed. The arsenite of copper is of an apple green, called Scheele's green.—The arsenite of silver is yellow—the arseniate, brick red.

The equivalent of arsenic is - - - - - -	4.75
Of arsenious acid, which contains two atoms oxygen, the equivalent is - - - - - - - - - -	6.75
Of arsenic acid, which contains three atoms of oxygen -	7.75

Besides these there is the black oxide, or protoxide, probably consisting of one atom metal, and one atom of oxygen.

OF ARSENURETTED HYDROGEN.

OF THE MEANS OF DETECTING ARSENIC IN FOOD OR DRINK, OR IN THE CONTENTS OF A STOMACH, IN CASES WHERE POISONING IS SUSPECTED.

EXPERIMENTAL ILLUSTRATIONS.

Habitudes of arsenic, as obtained by sublimation, in its metallic crystalline form, contrasted with those of zinc, antimony, and bismuth. White oxide, and its solutions, exhibited: also, Fowler's solution, or arsenite of potash. To large vessels of clear water, measured quantities of arsenic are added, and detected by various tests. Combustion of arsenuretted hydrogen displayed.

OF VARIOUS METALS OF MINOR IMPORTANCE.

OF RHODIUM, IRIDIUM, OSMIUM, COBALT, MANGANESE, CHROME, MOLYBDENUM, URANIUM, TUNGSTEN, TELLURIUM, SELENIUM, TITANIUM, COLUMBIUM, OR TANTALUM, CERIUM.

END OF THE MINUTES.

For the rest of the course, see "Supplement to the Minutes," containing lectures on vegetable and animal chemistry.

I shall conclude this volume with a quotation, from some tables, recently published by Dr. Thomson, in his Principles of Chemistry. In placing them before the medical student, I am actuated by the desire of facilitating, rather than enforcing, attention to the curious and useful knowledge which they contain.

TABLE I.

SPECIFIC GRAVITY OF THE GASES.

	SP. GRAVITY AT 60°.	WEIGHT OF 100 CUBIC INCHES IN GRAINS.
Air	1	30·5
Hydrogen	0·069$\dot{4}$	2·1180
Carbon vapour	0·416$\dot{6}$	12·608$\dot{3}$
Carburetted hydrogen	0·555$\dot{5}$	16·944$\dot{4}$
Ammonia	0·5902$\dot{7}$	18·003$\dot{5}$
Steam	0·625	19·0620
Phosphorus vapour	0·833$\dot{3}$	25·416$\dot{6}$
Phosphuretted hydrogen	0·902$\dot{7}$	27·5376
Hydrocyanic acid vapour	0·9375	28·5720
Bihydroguret of phosphorus	0·972$\dot{2}$	29·652$\dot{7}$
Carbonic oxide	0·972$\dot{2}$	29.652$\dot{7}$
Azotic gas	0·972$\dot{2}$	29·652$\dot{7}$
Olefiant gas	0·972$\dot{2}$	29·652$\dot{7}$
Deutoxide of azote	1·0416$\dot{6}$	31·7708
Oxygen	1·111$\dot{1}$	33·888$\dot{8}$
Sulphur vapour	1·111$\dot{1}$	33·888$\dot{8}$
Sulphuretted hydrogen	1·180$\dot{5}$	36·0069
Muriatic acid	1·2847$\dot{2}$	39·1839
Oil gas	1·458$\dot{3}$	44·4791$\dot{7}$
Carbonic acid	1·527$\dot{7}$	46·597$\dot{2}$
Protoxide of azote	1·527$\dot{7}$	46·597$\dot{2}$
Cyanogen	1·805$\dot{5}$	55·069$\dot{4}$
Protoxide of chlorine	2·444$\dot{4}$	74·555$\dot{5}$
Chlorine	2·5	76·25
Naphtha vapour	2·916$\dot{6}$	88·958$\dot{3}$
Nitric acid vapour	3·75	114·375
Oil of turpentine vapour	5·0130	152·8960

TABLE II.

SPECIFIC GRAVITY AND ATOMIC WEIGHTS OF THE GASES REFERRED TO OXYGEN GAS AS UNITY.

I. GASES WHOSE ATOMIC WEIGHT = SPECIFIC GRAVITY.

	ATOMIC WEIGHT.	SPECIFIC GRAVITY.
Oxygen gas	1	1
Fluosilicic acid	3·25	3·25

II. GASES WHOSE ATOMIC WEIGHT IS DOUBLE THE SPECIFIC GRAVITY.

a. Simple Bodies.

	ATOMIC WEIGHT.	SPECIFIC GRAVITY.
Hydrogen gas	0·125	0·0625
Carbon vapour	0·75	0·375
Phosphorus vapour	1·5	0·75
Azotic gas	1·75	0·875
Sulphur vapour	2	1
Tellurium vapour	4	2
Chlorine gas	4·5	2·25
Arsenic vapour	4·75	2·375
Selenium vapour	5	2·5
Iodine vapour	15·5	7·75

b. Compounds of Simple Combustibles and Hydrogen.

	ATOMIC WEIGHT.	SPECIFIC GRAVITY.
Carburetted hydrogen	1	0·5
Phosphuretted hydrogen	1·625	0·8125
Subphosphuretted hydrogen	1·25	0·625
Bihydroguret of phosphorus	1·75	0·875
Olefiant gas	1·75	0·875
Oil gas	2·625?	1·3175?
Sulphuretted hydrogen	2·125	1·0625
Telluretted hydrogen	4·125	2·0625
Oil of turpentine	9·125?	4·5625?
Arsenietted hydrogen	4·875	2·4375
Selenietted hydrogen	5·125	2·5625

c. Compounds of Simple Combustibles and Oxygen.

	ATOMIC WEIGHT.	SPECIFIC GRAVITY.
Steam	1·125	0·5625
Carbonic oxide gas	1·75	0·875
Carbonic acid	2·75	1·375
Protoxide of azote	2·75	1·375
Nitric acid vapour	6·75	3·375
Sulphurous acid	4	2
Sulphuric acid vapour	5	2·5

d. Miscellaneous Compounds.

	ATOMIC WEIGHT.	SPECIFIC GRAVITY.
Cyanogen	3·25	1·625
Fluoboric acid	4·25	2·125
Bisulphuret of carbon	4·75	2·375
Chlorocarbonic acid	6·25	3·125

III. GASES WHOSE ATOMIC WEIGHT IS QUADRUPLE THE SPECIFIC GRAVITY.

	ATOMIC WEIGHT.	SPECIFIC GRAVITY.
Ammoniacal gas	2·125	0·53125
Hydrocyanic acid vapour	3·375	0·84375
Deutoxide of azote	3·75	0·9375
Muriatic acid	4·625	1·15625
Hydriodic acid	15·625	3·90625

TABLE III.

ATOMIC WEIGHTS, OR CHEMICAL EQUIVALENTS, ALPHABETICALLY ARRANGED.

☞ *See Thomson's Principles of Chemistry, vol.* 1, *p.* 94.

	ATOMIC WEIGHTS. Oxy. = 1		ATOMIC WEIGHTS. Oxy. = 1
Acetic acid	6·25	Chloride of potassium	9·5
Ditto, in crystals	7·375	silver	18·25
Alcohol	2·875	sodium	7·5
Alum	60·875	strontium	10
Alumina	2·25	sulphur	6·5
Aluminum	1·25	tin	11·75
Ammonia	2·125	Chloride of zinc	8·75
Antimony	5·5	Chlorine	4·5
Arsenic	4·75	Chromate of lead	20·5
Arsenic acid	7·75	Chromic acid	6·5
Arsenious acid	6·75	Citric acid	7·25
Azote	1·75	Ditto, in crystals	9·5
		Copper	4
Barium	8·75	Cyanogen	3·25
Barytes	9·75		
Bitartrate of potash	20·125	Ether, sulphuric	4·625
Boracic acid	3		
Boron	1	Fuming sulphuric acid	11·125
Brucia	51·5		
		Gallic acid	7·75 ?
Calcium	2·5	Gold	25
Carbon	0·75	Gum	11·25
Carbonate of ammonia	3·875		
barytes	12·5	Hydrogen	0·125
iron	7·25	Hyposulphurous acid	3
lead	16·75		
lime	6·25	Iodine	15·5
magnesia	8·625	Iron	3·5
potash	11		
soda	18	Kermes mineral	8·625
Carbonic acid	2·75		
oxide	1·75	Lead	13
Carburetted hydrogen	1	Lime	3·5
Chloride of antimony	10	Lithia	2·25
copper	8·5	Lithium	1·25
mercury	29·5		
platinum	16·5	Magnesia	2·5

Opium may be detected in this way — boil the drug with water — pour in acetate of lead, and the meconate of lead is precipitated to the bottom, & then thro' a tube sulphuretted acid is poured — & then the sulphate of iron, by which the Meconic acid is detected

	ATOMIC WEIGHTS. Oxy. = 1
Mercury	25
Morphia	40·25
Muriate of barytes	15·5
copper	11·875
iron	12·5
lime	14·875
Muriatic acid	4·625
Nickel	3·25
Nitrate of ammonia	10
barytes	16·5
iron	19·125
lead	20·75
lime	17
mercury	35
potash	12·75
silver	21·5
soda	10·75
Nitrous acid	5·75
Nitric acid	6·75
Oil gas	2·625
Olefiant gas	1·75
Oxalate of ammonia	8·875
potash	11·625
lime	10.25
Oxalic acid	4·5
Oxide of bismuth	10
copper	5
silver	14·75
zinc	5·25
Oxygen	1
Palladium	7
Perchloric acid	11·5
Peroxide of antimony	7·5
gold	28
iron	5
lead	15
mercury	27
platinum	14
potassium	8
tin	9·25
Phosphate of ammonia	7·875
iron	11·375
lead	17·5
potash	10·625
silver	18·25
soda	21
Phosphoric acid	3·5
Phosphorous acid	2·5
Phosphorus	1·5
Phosphuretted hydrogen	1·625
Picrotoxia	45
Platinum	12
Potash	6
Potassium	5
Protoxide of antimony	6·5
gold	26

	ATOMIC WEIGHTS. Oxy. = 1
Protoxide of iron	4·5
lead	14
platinum	13
potassium	6
sodium	4
tin	8·25
Red oxide of lead	14·5
Silica	2
Silicon	1
Silver	13·75
Soda	4
Sodium	3
Starch	17·75
Strontian	6·5
Strontium	5·5
Strychnia	47·5 ?
Suboxide of copper	9
Succinate of ammonia	10·625
Succinic acid	6·25
Sugar	10·125
Sulphate of alumina	15·125
ammonia	8·25
barytes	14·75
copper	15·625
iron	17·375
lead	19
lime	10·75
magnesia	15·375
mercury	33·25
potash	11
silver	19·75
soda	20·25
strontian	11·5
zinc	18·125
Sulphur	2
Sulphuret of antimony	7·5
arsenic	6·75
calcium	4·5
copper	6
iron	5·5
lead	15
mercury	27
potassium	7
silver	15·75
sodium	5
zinc	6·25
Sulphuretted hydrogen	2·125
Sulphuric acid	5
ether	4·625
Sulphurous acid	4
Tannin	8·75 ?
Tartar emetic	44·25
Tartaric acid	8·25
crystals	9·375
Tartrate of iron	15
lead	22·25

	ATOMIC WEIGHTS. Oxy. = 1		ATOMIC WEIGHTS. Oxy. = 1
Tartrate of lime . .	16·25	Uric acid crystals . .	11·25
potash . .	16·5		
Tin	7·25	Water	1·125
Urate of soda . . .	14·125	Zinc	4·25
Uric acid	9		

In charging a Leyden Jar, the repulsive power is inversely as the square of the distances thro which it acts, hence a piece of mica and admits of greater thickness with requisite density, can receive a much superior charge of electric matter.

16 : 12 : 8

8

16)96(6

96

E.b. = 16a = a8 + b8

Nr. C = 12

E. J = 8 =

Nr. J = 6

Mr. Amsterdam